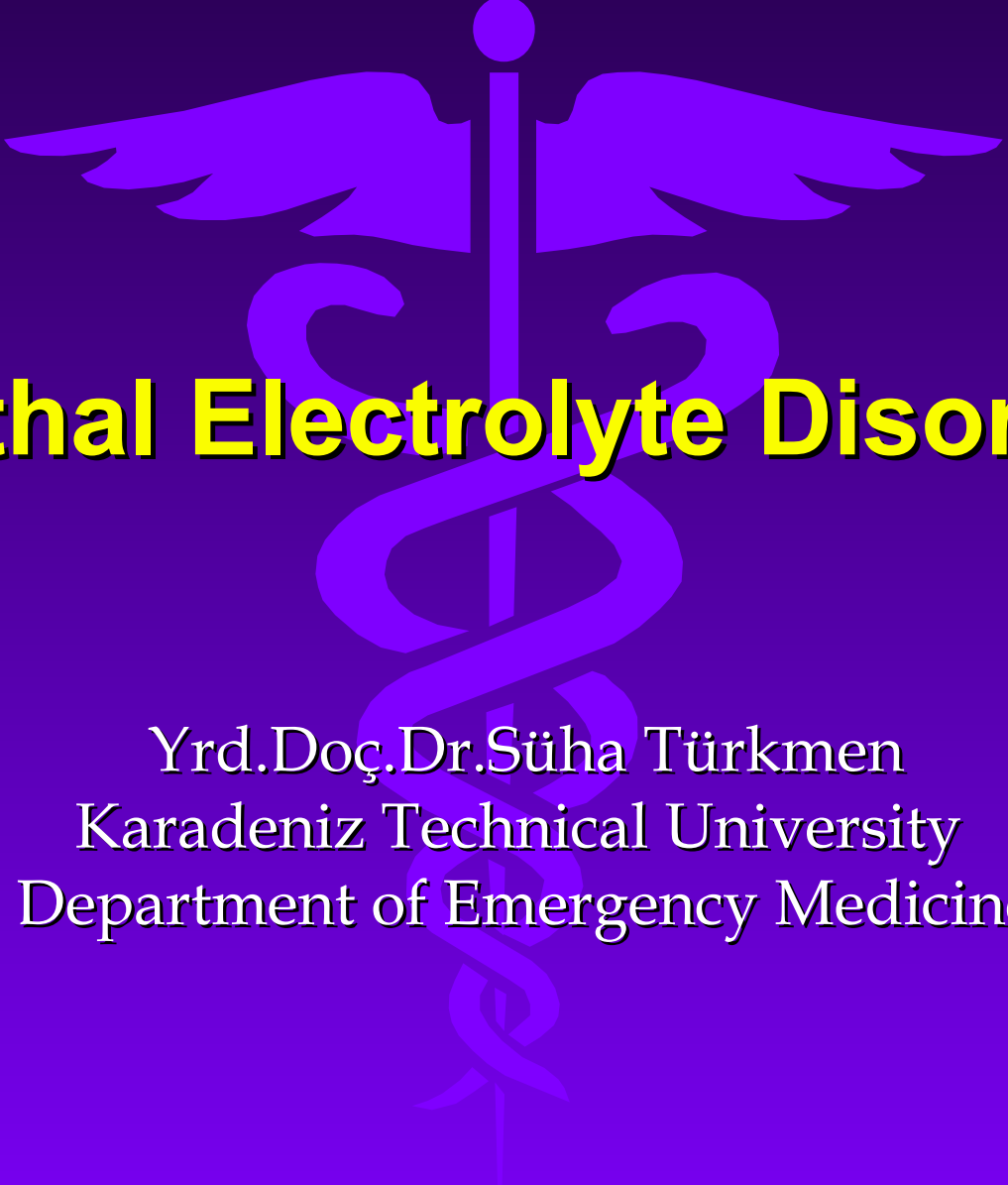
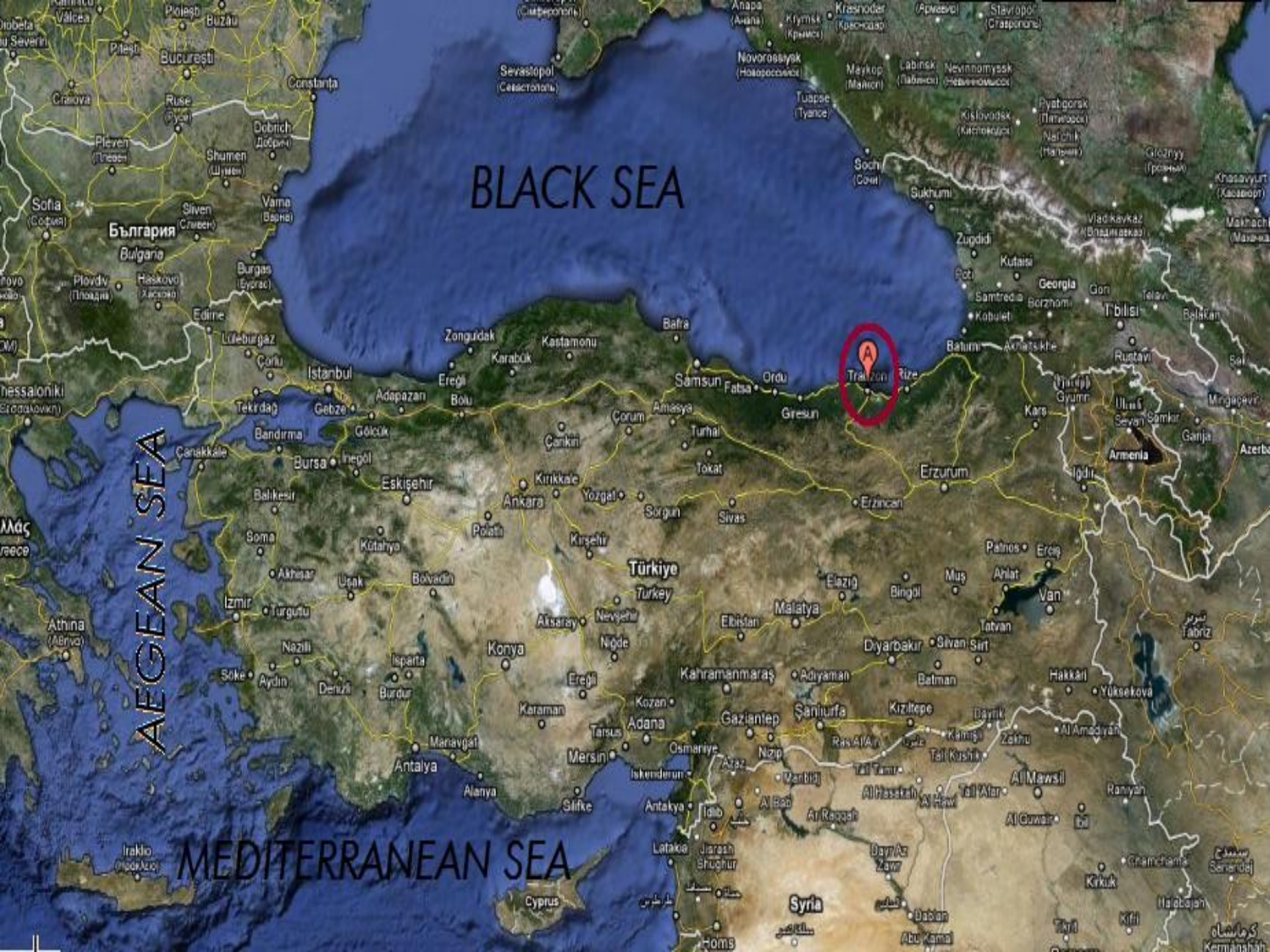




Lethal Electrolyte Disorders

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Karadeniz Technical University
Department of Emergency Medicine



BLACK SEA

AEGEAN SEA

MEDITERRANEAN SEA



Türkiye

Syria

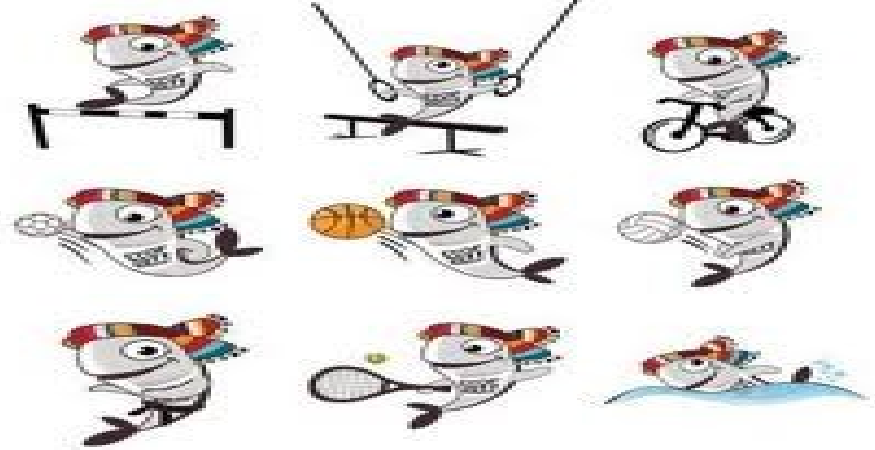
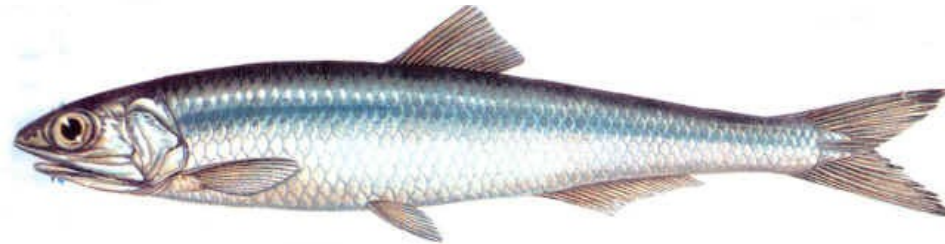






GÜNAHLARINI
VE SEVAPLARINI
ÖLÇTÜK. İKİSİ DE EŞİT
ÇIKTI. CENNET Mİ İSTERSİN
CEHENNEM Mİ?

FARKETMEZİ
BİZE HER YER
TRABZON



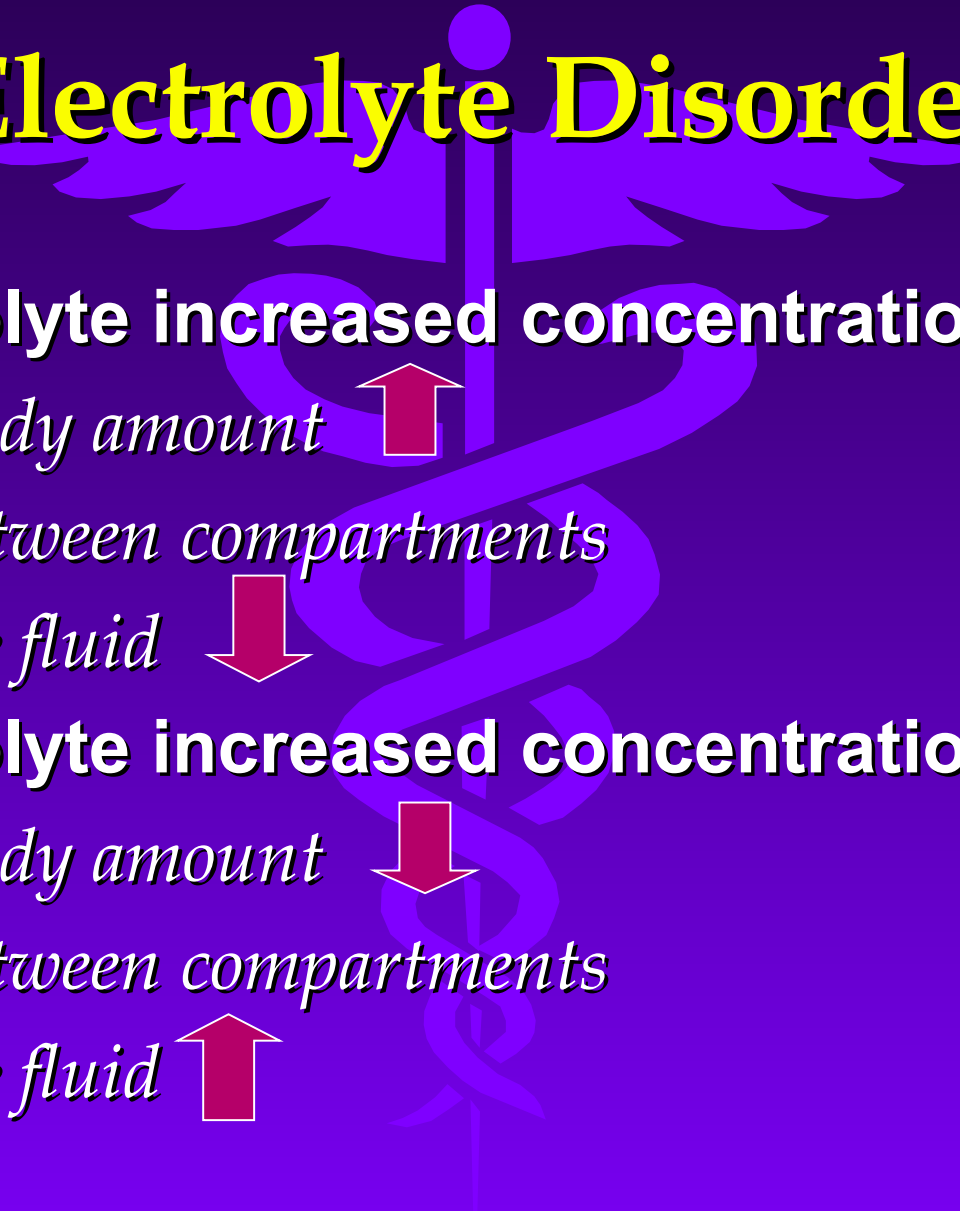
Hamsi

Anchovy
Anchois commune
Sardelle

Compartments

Değişken	Total body fluid	ICF	ECF	IF	IVF
Total Body weight	%60	%40	%20	%15	%5
Total Body weight		%67	%33	%25	%8
ECF				%75	%25

Electrolyte Disorder

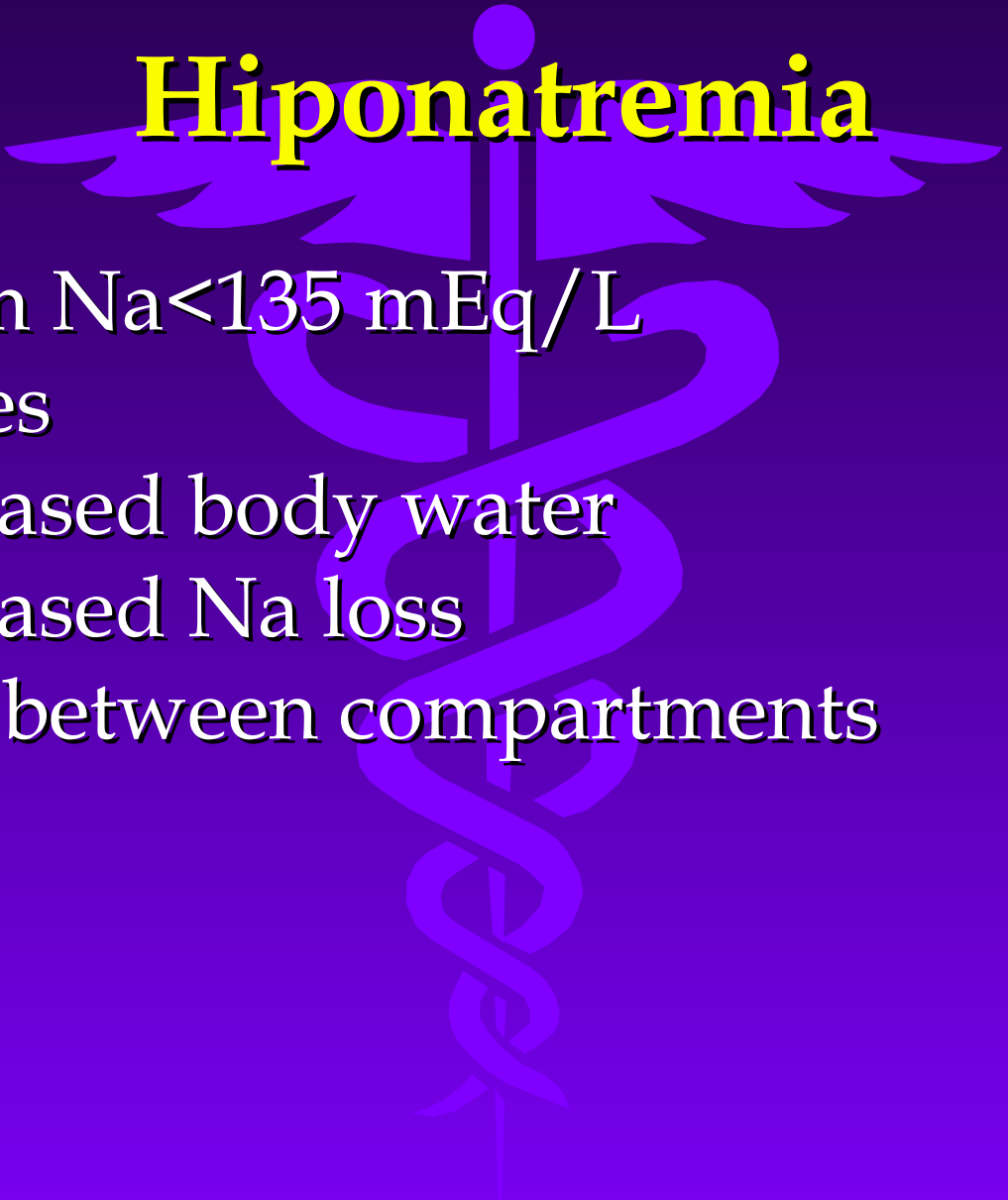


- **Electrolyte increased concentration (hyper-)**
 - *Total body amount* ↑
 - *Shift between compartments*
 - *Relative fluid* ↓
- **Electrolyte decreased concentration (hypo-)**
 - *Total body amount* ↓
 - *Shift between compartments*
 - *Relative fluid* ↑

Normal Values

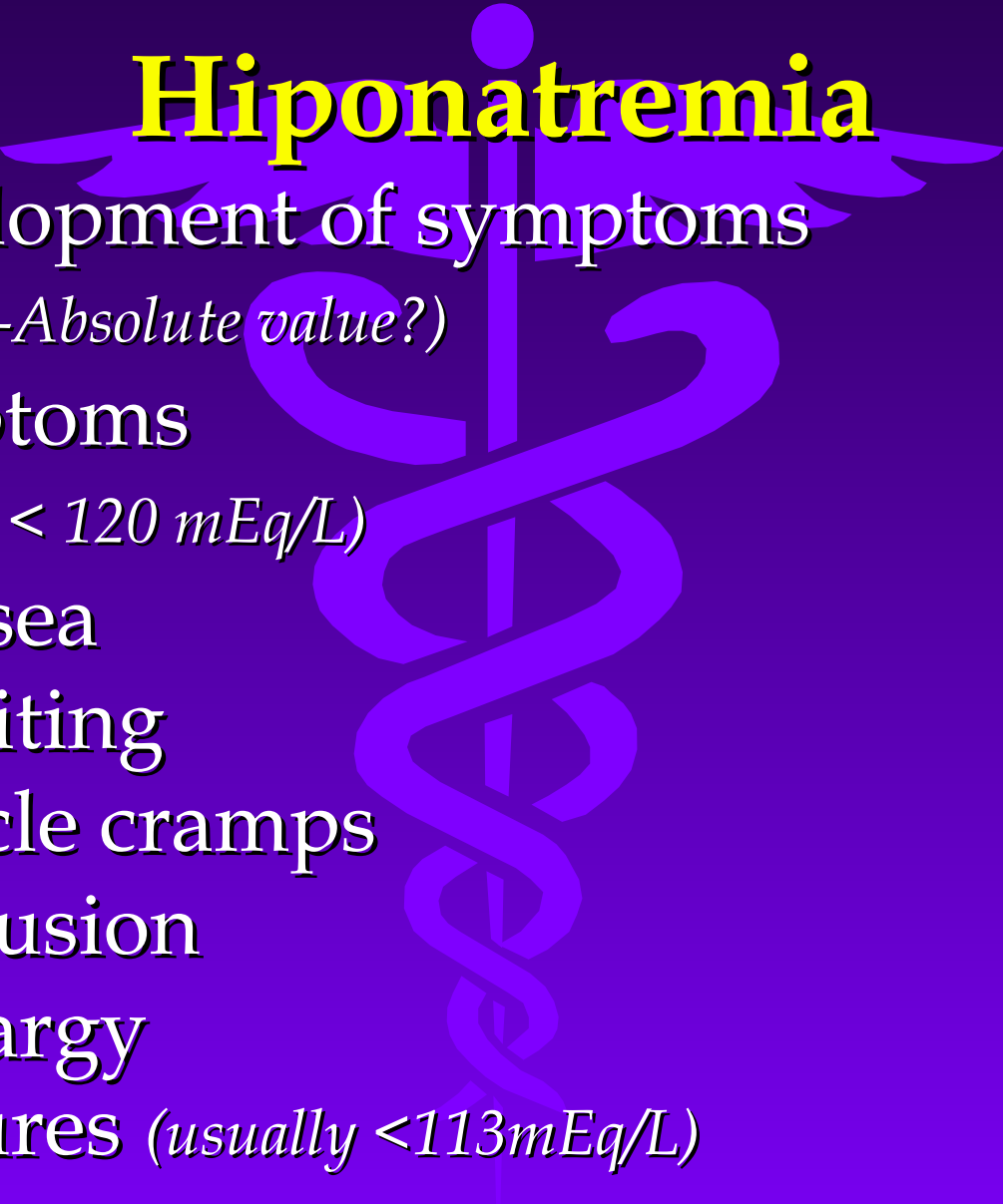
Serum osmolarity (Number of osmoles per liter of solution) ($2 \times \text{Na} + \text{Glucose}/18 + \text{BUN}/2.8$)	275-295 mOsm/L
Sodium (Na)	135-145 mEq/L
Potassium (K)	3.5-5.0 mEq/L
Calcium (Ca)	8.5-10.5 mg/dL
Magnesium (Mg)	1.5-2.5 mEq/L

Hiponatremia



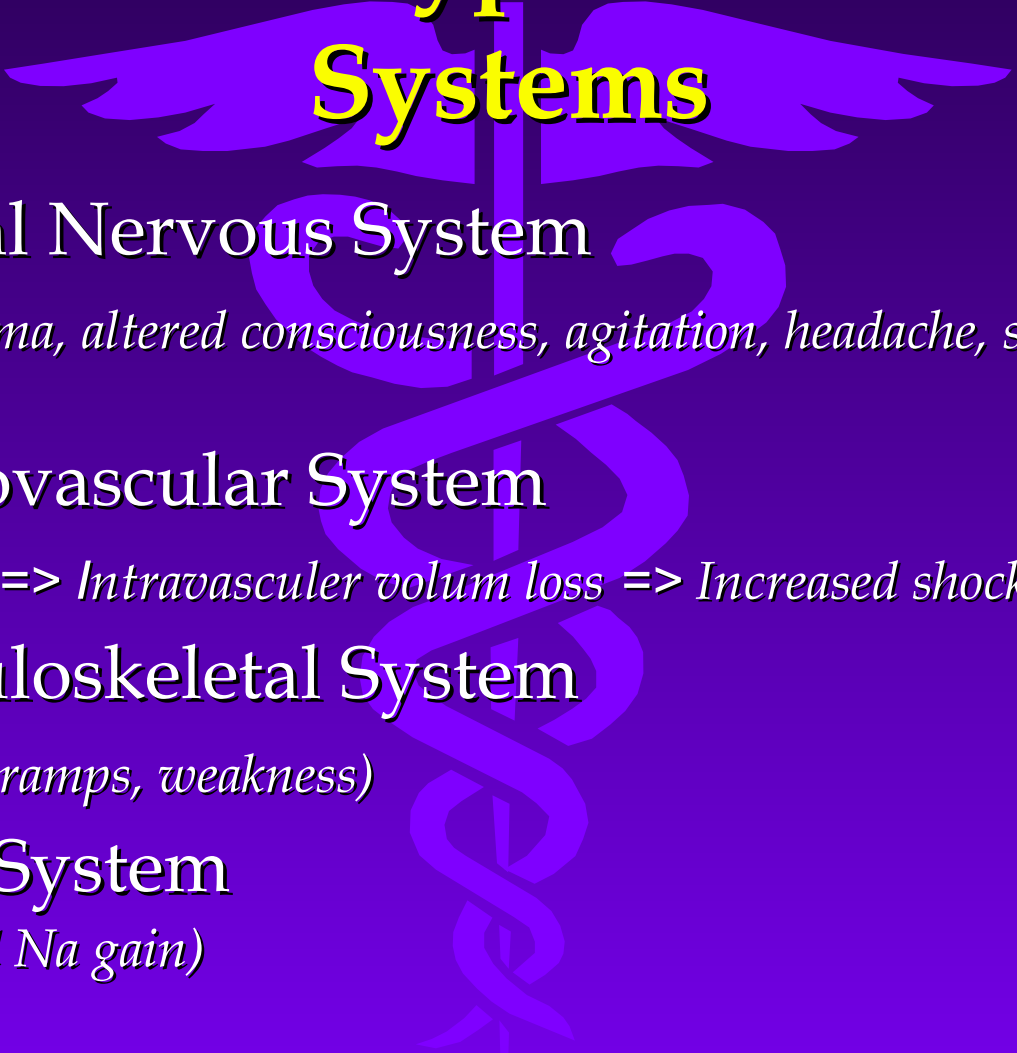
- Serum Na < 135 mEq/L
- Causes
 - Increased body water
 - Increased Na loss
 - Shift between compartments

Hiponatremia



- Development of symptoms
(*Rate? - Absolute value?*)
- Symptoms
(*usually < 120 mEq/L*)
- -Nausea
 - Vomiting
 - Muscle cramps
 - Confusion
 - Lethargy
 - Seizures (*usually < 113 mEq/L*)
 - Coma

Effects of Hyponatremia on Systems



- Central Nervous System

(Brain edema, altered consciousness, agitation, headache, seizures, coma)

- Cardiovascular System

(HipoNa => Intravascular volum loss => Increased shock risk)

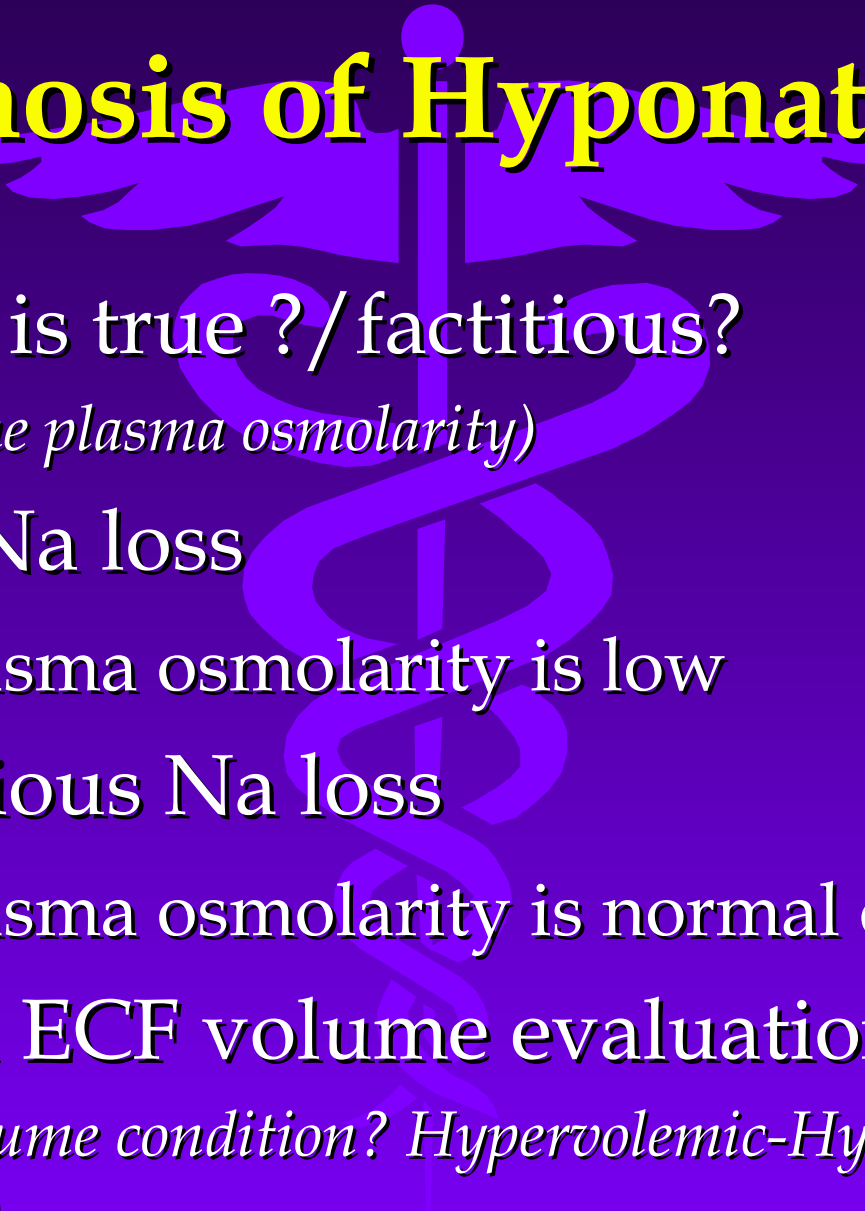
- Musculoskeletal System

(Muscle cramps, weakness)

- Renal System

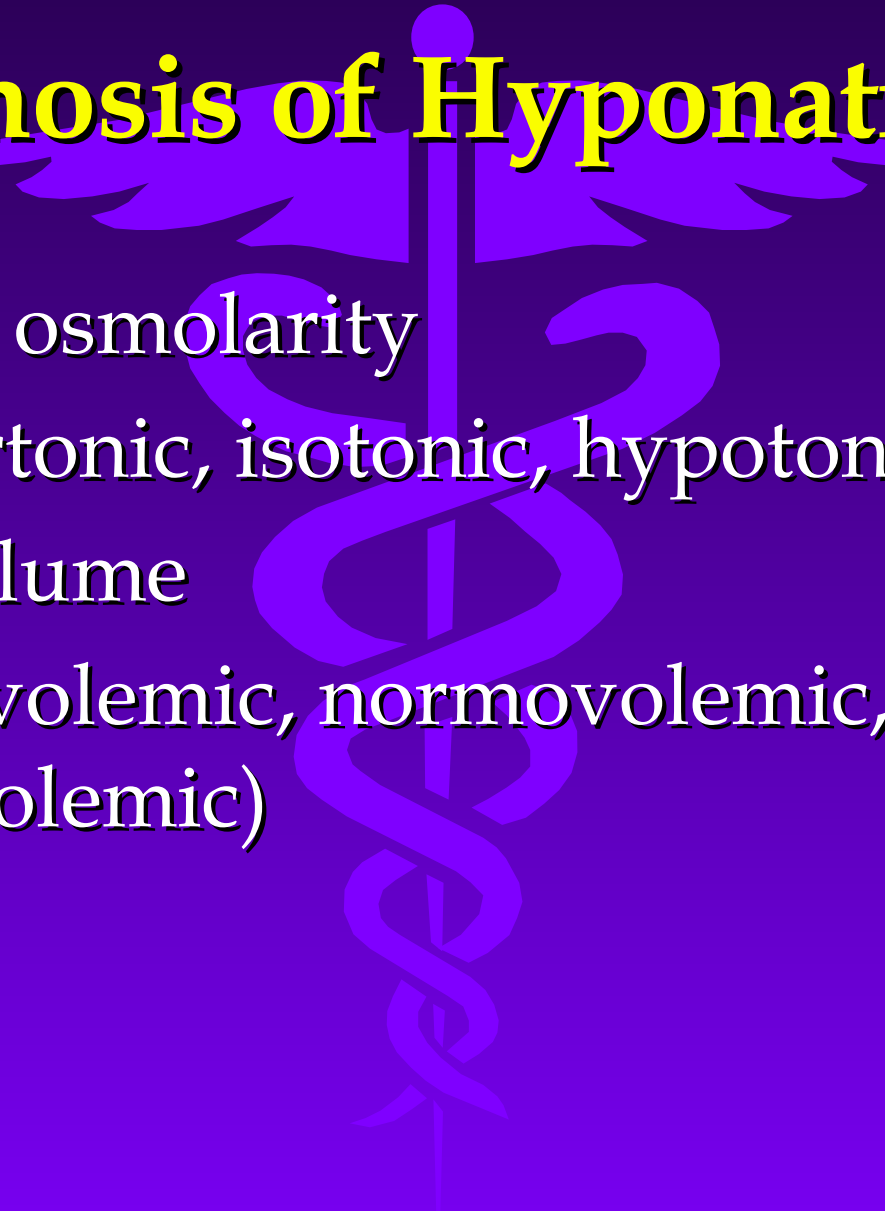
(Increased Na gain)

Diagnosis of Hyponatremia



- Na loss is true ?/ factitious?
(Look at the plasma osmolarity)
 - True Na loss
=> plasma osmolarity is low
 - Factitious Na loss
=> plasma osmolarity is normal or high
- Clinical ECF volume evaluation
(Patient volume condition? Hypervolemic-Hypovolemic-Euvolemic)

Diagnosis of Hyponatremia



- Plasma osmolarity
(Hypertonic, isotonic, hypotonic)
- ECF volume
(Hypovolemic, normovolemic, hypervolemic)

Hypertonic Hyponatremia

(Plasma osmolarity > 295)

- Large quantities of osmotically active solutes accumulate in the ECF
- Movement of water from ICF to the ECF, thereby diluted hyponatremia
- Hyperglycemia
(Glucose 100 mg/dl increase → Na 1.6-1.8 decrease)
- Mannitol excess
- Glycerol therapy

Isotonic Hyponatremia

(Plasma osmolarity 275-295)

- Pseudohyponatremia
- High levels of plasma proteins and lipids cause diluated hyponatremia
- Hyperlipidemia
- Hyperproteinemia

(Multiple myeloma, Waldenström
macroglobulinemia)

Hypotonic Hyponatremia

(Plasma osmolarity < 275)

- Hypovolemic
- Hypervolemic
- Normovolemic



- Urinary Na > 20 mEq/L

(Renal)

- Urinary Na < 20 mEq/L

(Extrarenal)

Hypotonic Hypovolemic Hyponatremia

(Plasma osmolarity < 275)

- Renal causes (Urinary Na > 20 mEq/L)
 - Diuretic use
 - Renal Tubular Acidosis
 - Chronic renal failure
 - Interstitial nephritis
 - Osmotic diuresis
- Extrarenal causes (Urinary Na < 20 mEq/L)
 - Volume replacement with hypotonic fluids
 - Gastrointestinal loss
 - Third space loss
 - Sweating (Cystic fibrosis)



Hypotonic Hypovolemic Hyponatremia

(Plasma osmolarity < 275)

- Treatment
 - Reexpansion of the ECF volume
(isotonic saline)
 - Correction of underlying disorder

Hypotonic Hypervolemic Hyponatremia

(Plasma osmolarity < 275)

- Renal causes
(Urinary Na > 20mEq/L)
 - Renal failure
- Extrarenal causes
(Urinary Na < 20mEq/L)
 - Congestif heart failure
 - Nephrotic syndrome
 - Cirrhosis



Hypotonic Hypervolemic Hyponatremia

(Plasma osmolarity < 275)

- Treatment
 - Water and salt restriction
 - Treatment of underlying disorder
 - Diuretics
 - Dialysis

Hypotonic Euvolemic Hyponatremia

(Plasma osmolarity < 275)

- Normal volume status
- Usually urinary Na > 20mEq/L
- Causes
 - Syndrome of inappropriate secretion of ADH
 - Hypothyroidism
 - Psychogenic polydipsia
 - Porphria
 - **Drugs** (ADH, nicotine, sulfonylureas, morphine, acetaminophen, carbamazepine, phenothiazines, colchicine, clofibrate, vincristine, MAO inhibitor)

Hypotonic Euvolemic Hyponatremia

(Plasma osmolarity < 275)

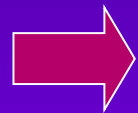
- Treatment
 - Fluid restriction
 - Management of the underlying disorder

Diagnostic Criteria for Syndrome of Inappropriate Section of ADH

- Hypotonic hyponatremia
- Normovolemic
- Elevated urinary osmolality
(>200 mOsm/kg)
- Urinary Na $\uparrow$ (>20 mEq/L)
- Normal functions
(Adrenal/renal/kardiak/hepatic/thyroid)
- Correctable with water restriction

Treatment of Hyponatremia

- Severe hyponatremia ($<120\text{mEq/L}$)
- Develops rapid ($>0.5\text{mEq/L/sa}$)
- Seizures-Coma

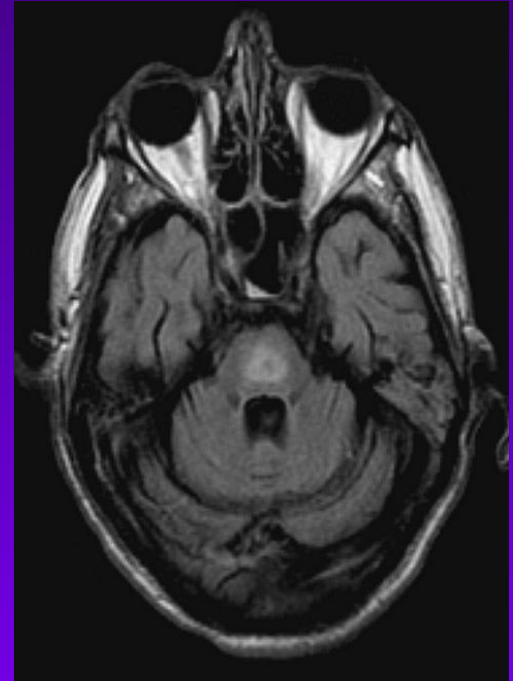


%3 saline solution (513mEq/L)

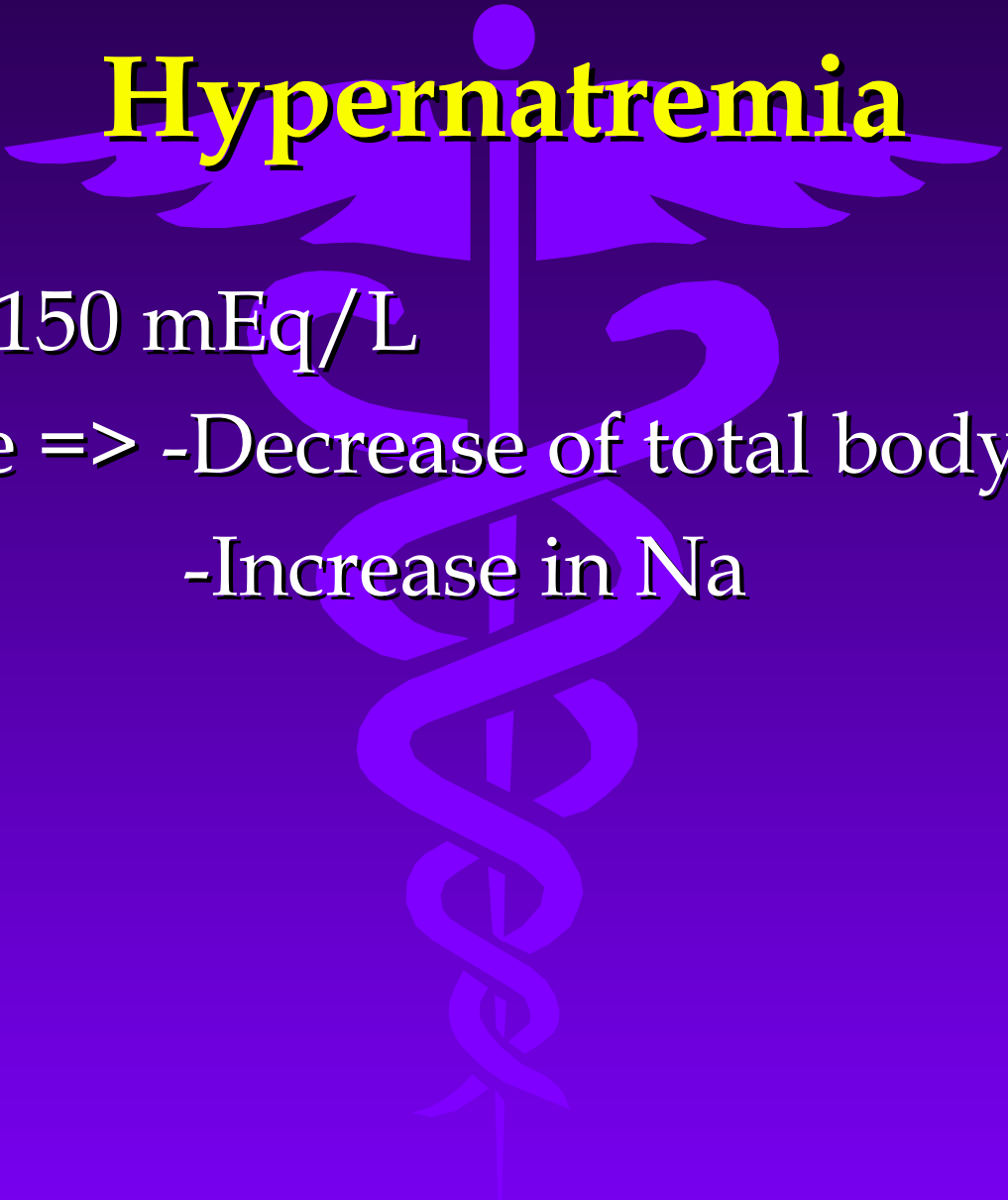
(Rise plasma Na $0.5\text{-}1\text{mEq/L/sa}$)

Central Pontine Myelinolysis

- Occurs in %2
- High risk in patients with chronic hyponatremia
- Clinic
 - Fluctuating levels of consciousness
 - Behavioral disturbances
 - Dysarthria
 - Dysphagia
 - Convulsion
 - Pseudobulbar palsy
 - Quadripareisis

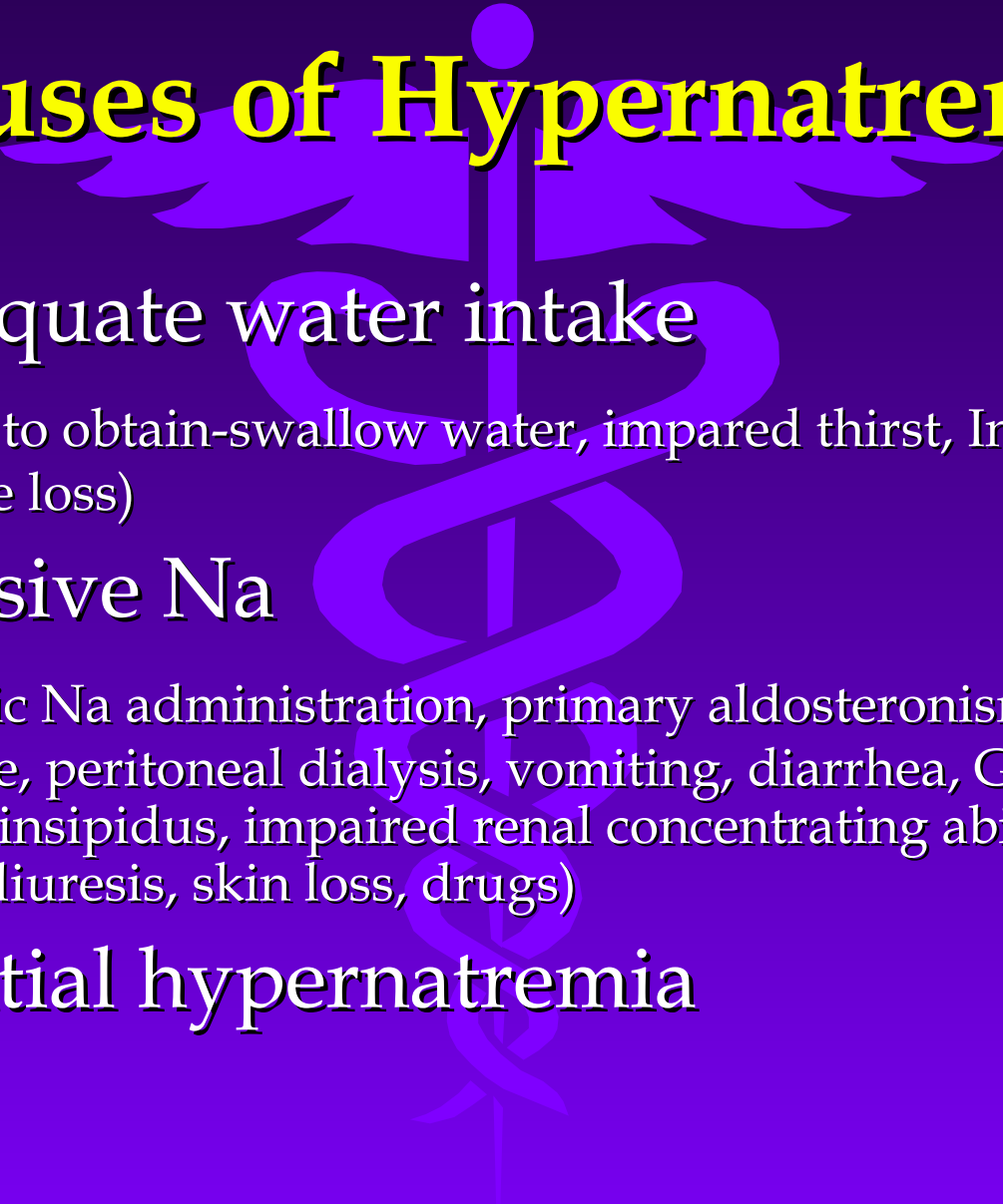


Hypernatremia



- $\text{Na} > 150 \text{ mEq/L}$
- Cause $\Rightarrow$ -Decrease of total body fluid
-Increase in Na

Causes of Hypernatremia



- Inadequate water intake

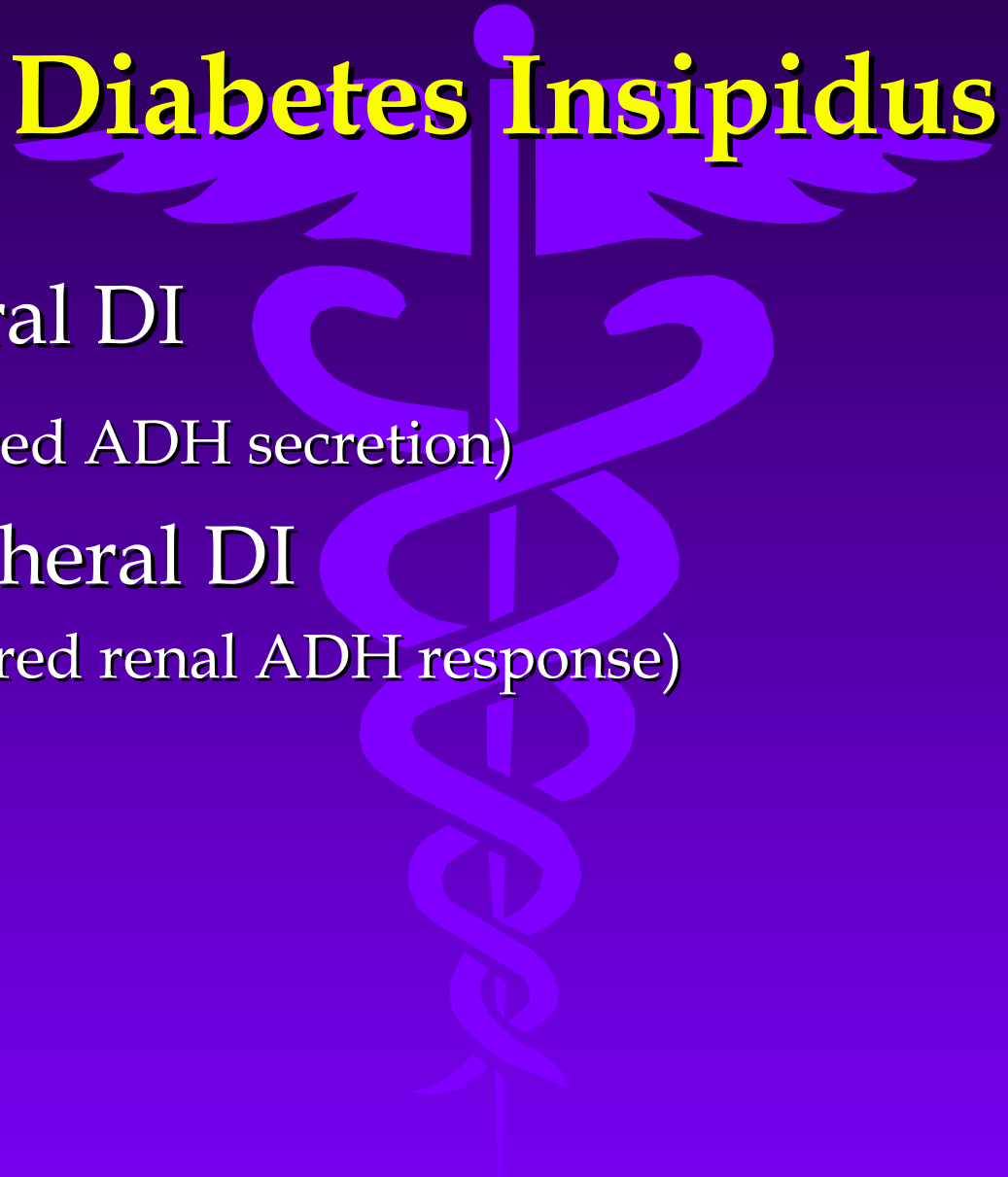
(Inability to obtain-swallow water, impaired thirst, Increased insensible loss)

- Excessive Na

(Iatrogenic Na administration, primary aldosteronism, cushing syndrome, peritoneal dialysis, vomiting, diarrhea, GI fistula, Diabetes insipidus, impaired renal concentrating ability, osmotic diuresis, skin loss, drugs)

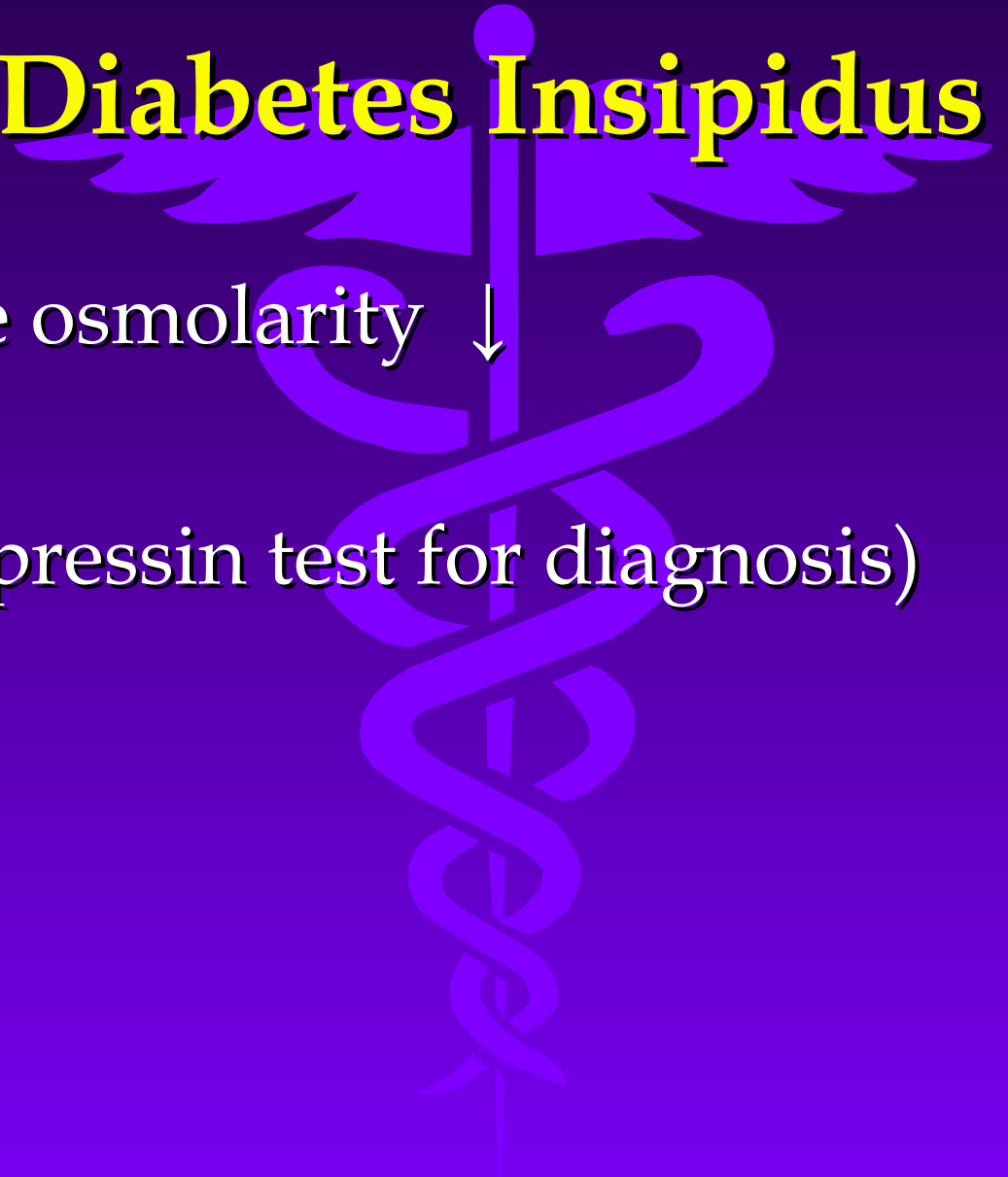
- Essential hypernatremia

Diabetes Insipidus



- Central DI
(Impaired ADH secretion)
- Peripheral DI
(Impaired renal ADH response)

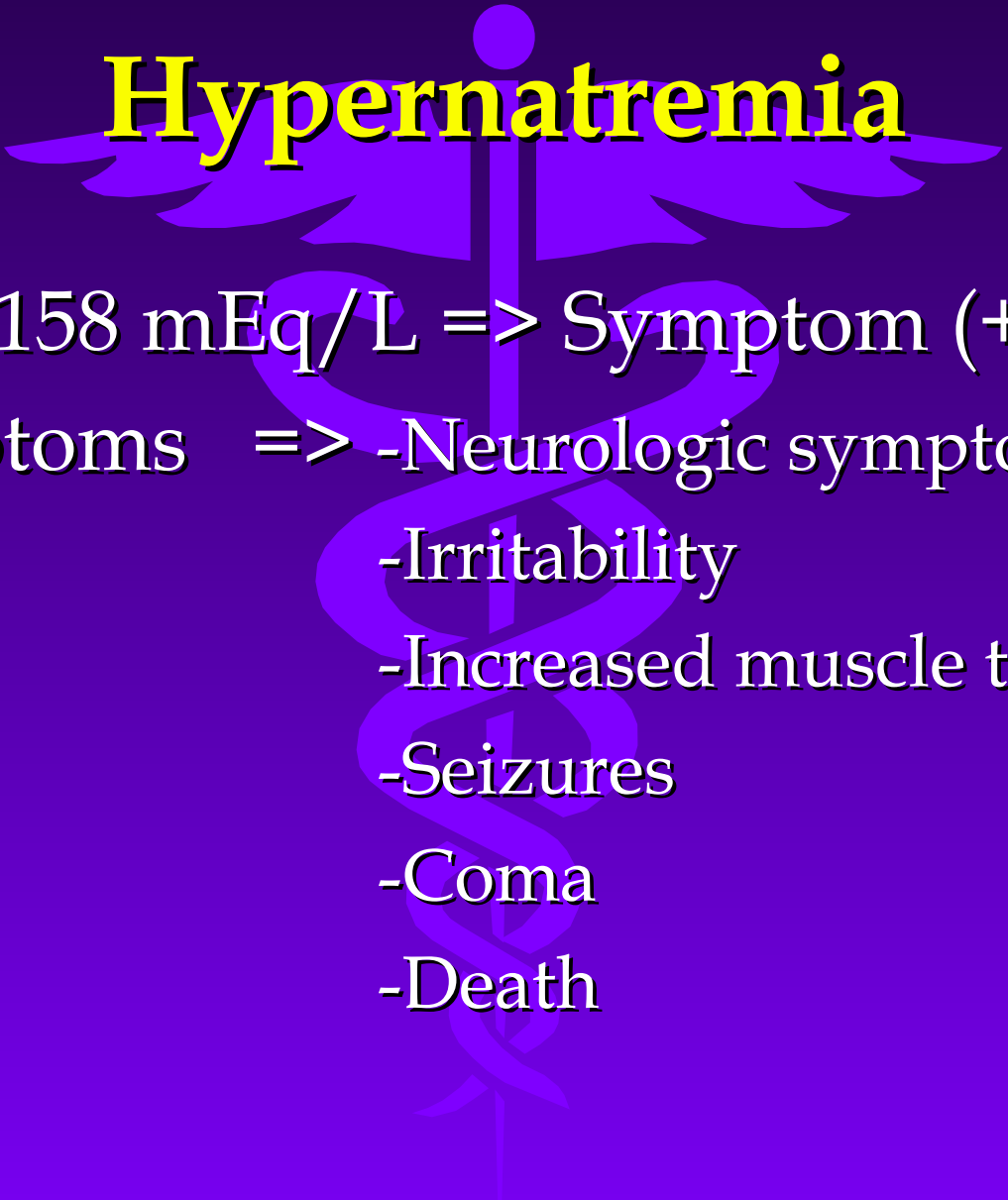
Diabetes Insipidus



- Urine osmolarity ↓

(Vasopressin test for diagnosis)

Hypernatremia

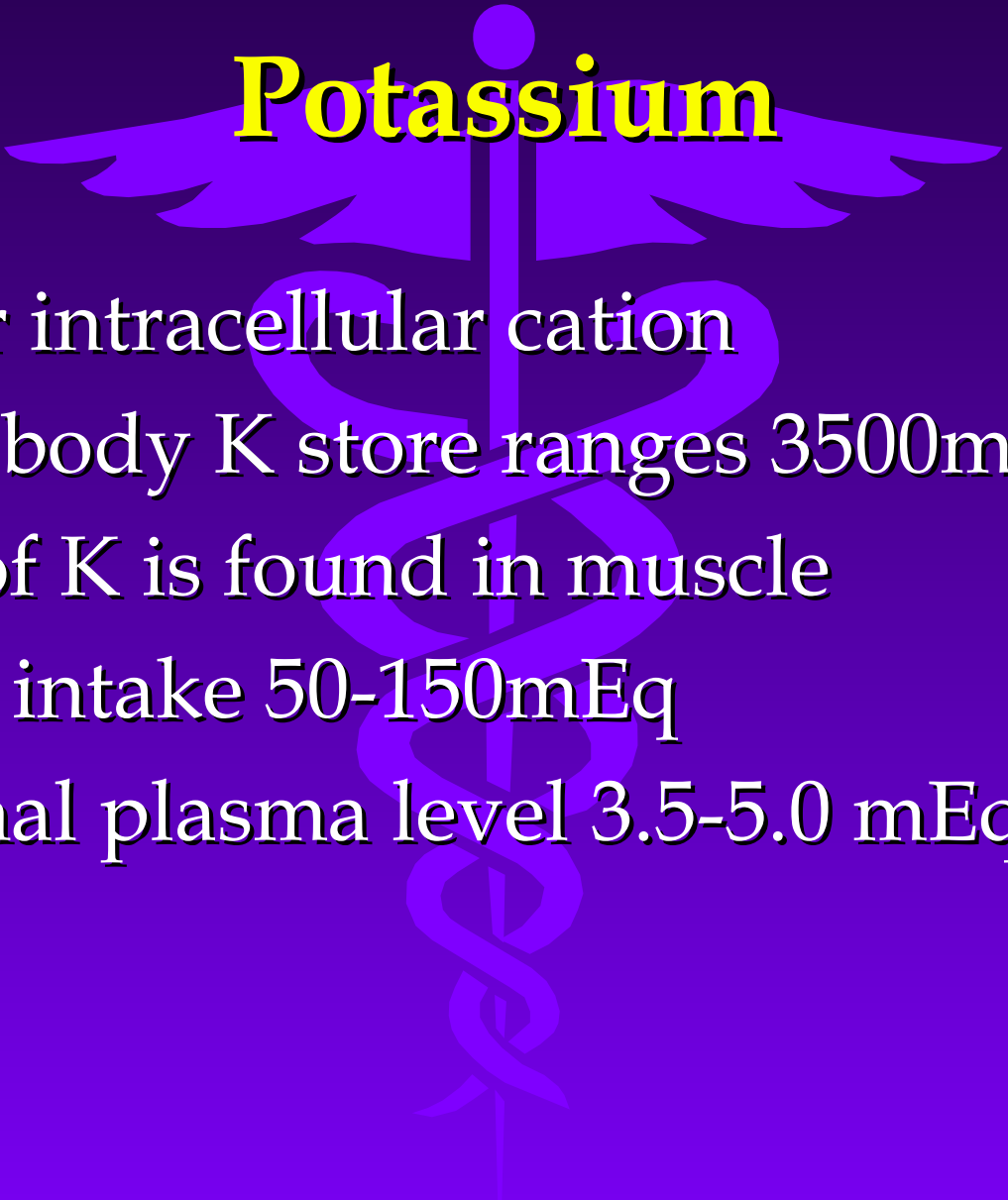


- $\text{Na} > 158 \text{ mEq/L} \Rightarrow \text{Symptom (+)}$
- Symptoms $\Rightarrow$
 - Neurologic symptoms
 - Irritability
 - Increased muscle tone
 - Seizures
 - Coma
 - Death

Treatment of Hypernatremia

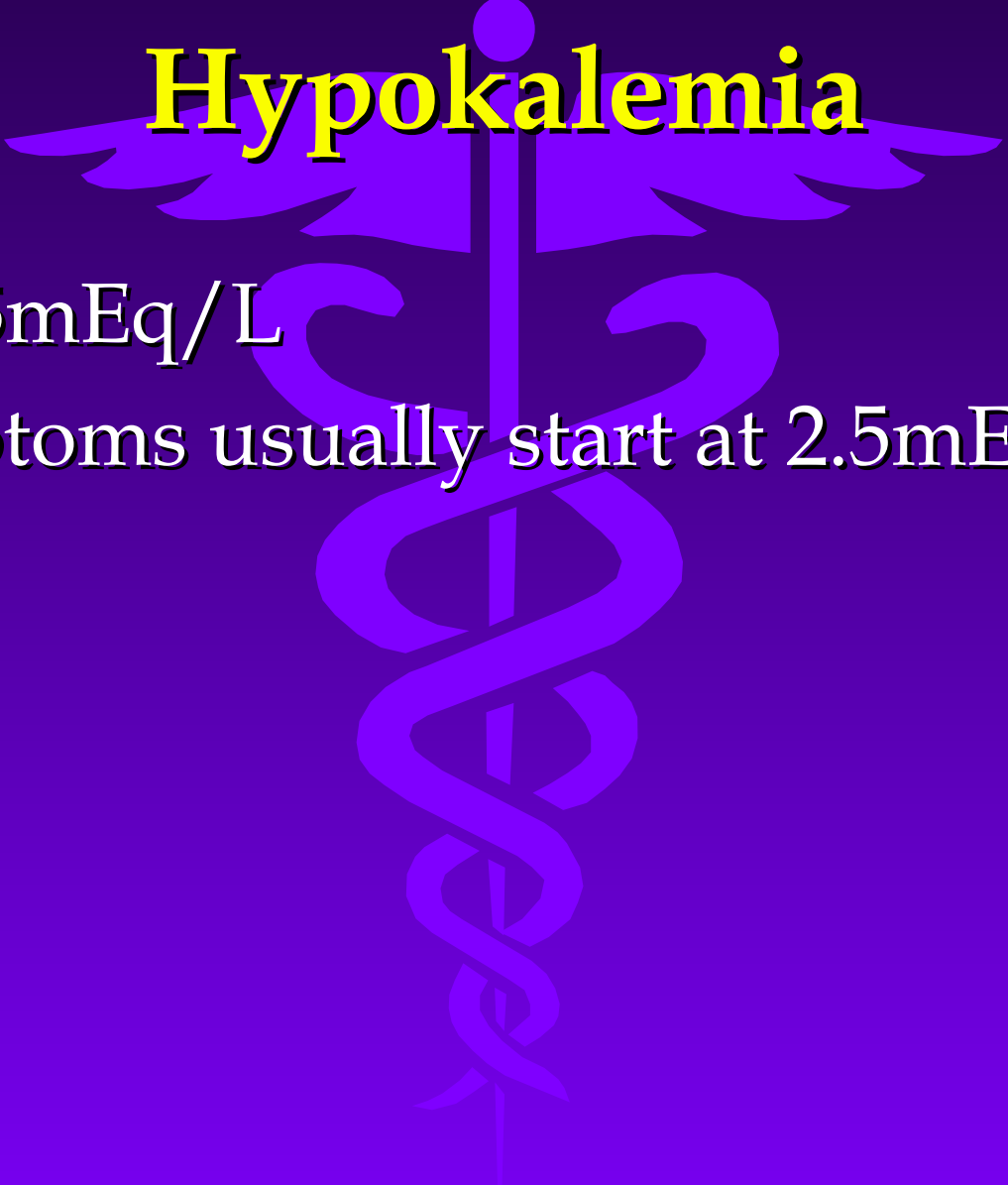
- Volume repletion
(Replace with saline or RL
=> Once perfusion has been established
=> Convert to 0.45% saline or other hypotonic solutions)
- Water deficit (L) = $\frac{\text{Patient Na} - 140}{140} \times 0.5 \times \text{kg}$
(Example : Water deficit = $\frac{160 - 140}{140} \times 0.5 \times 70 = 5 \text{ L}$)
- The reduction in Na should not exceed 10-15mEq/L per day

Potassium



- Major intracellular cation
- Total body K store ranges 3500mEq
- %75 of K is found in muscle
- Daily intake 50-150mEq
- Normal plasma level 3.5-5.0 mEq/L

Hypokalemia



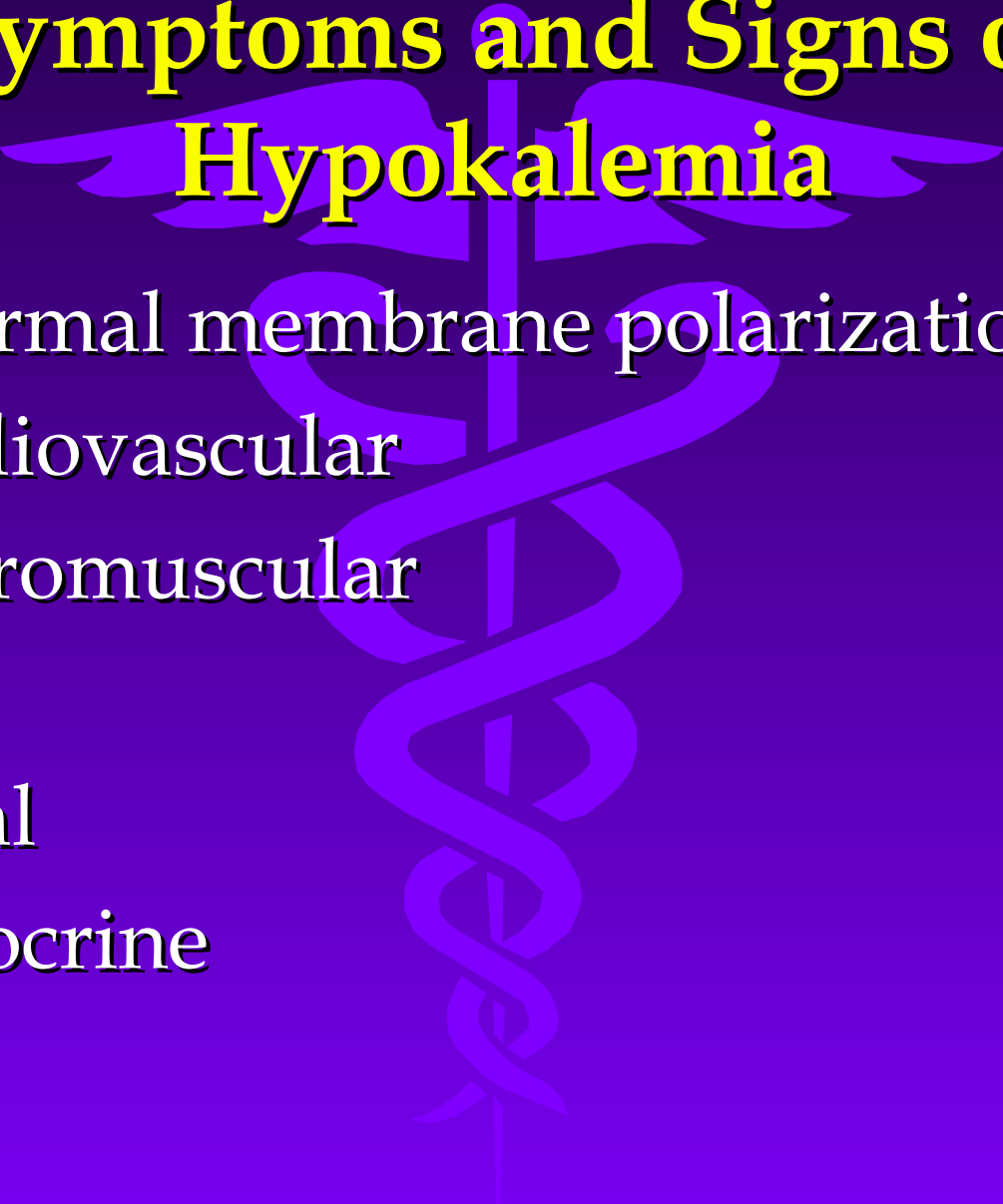
- $K < 3.5 \text{ mEq/L}$
- Symptoms usually start at 2.5 mEq/L

Causes of Hypokalemia



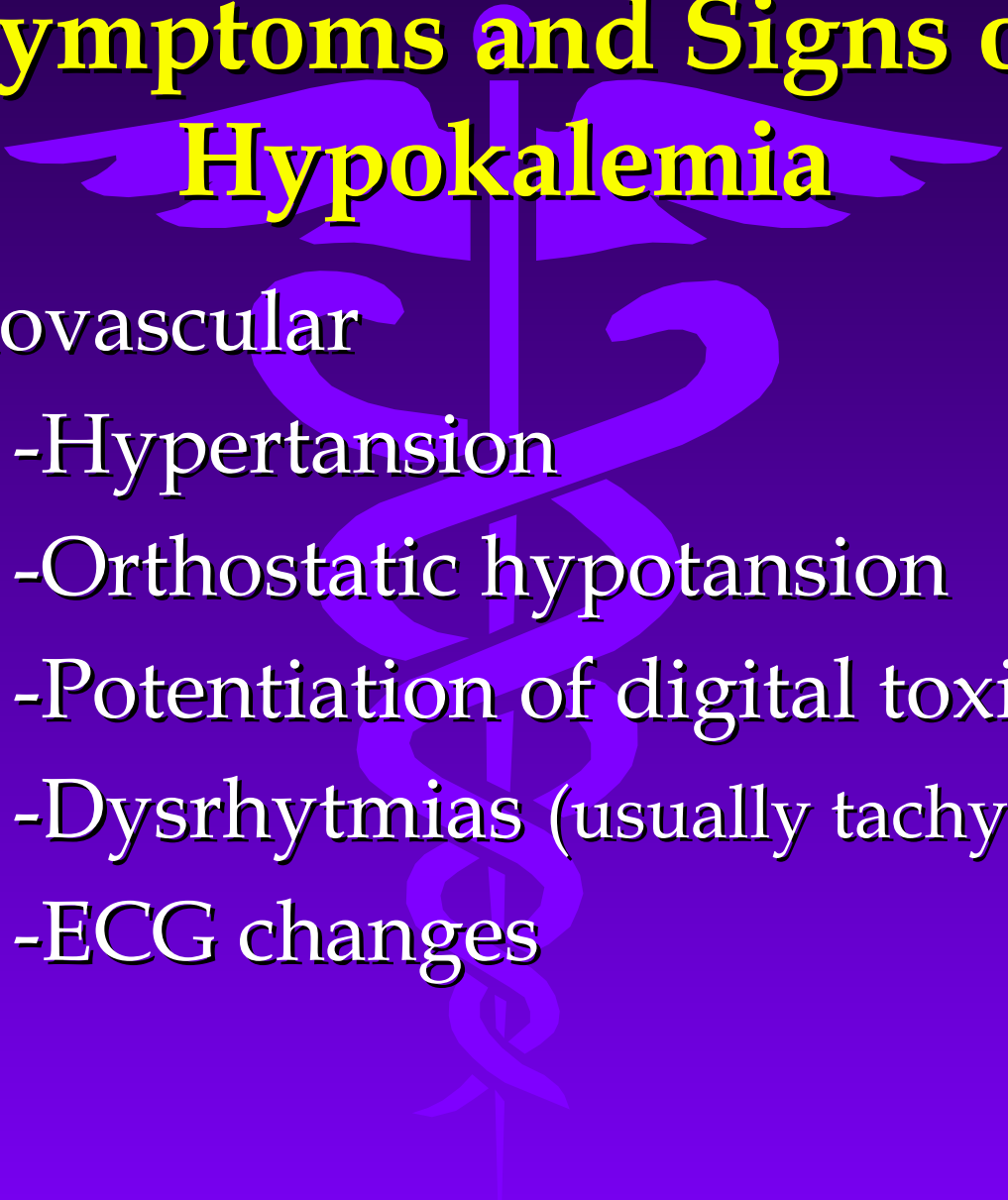
- Extracellular to intracellular shifts
(Alkalosis, Increased plasma insulin, Beta-adrenergics, hypokalemic periodic hypokalemia)
- Decreased intake
- GI loss
(Vomiting, nasogastric loss, diarrhea, malabsorption, enteric fistula)
- Renal loss
(Diuretic, pr/sec aldesteronism, renal tubuler acidosis, osmotic diuresis)
- Drugs and toxins
(Penicilin, carbenicillin, amphotericin-B, lithium, dopamine)
- Sweat loss
- Other
(Hypomagnesemia, acute leukemia)

Symptoms and Signs of Hypokalemia



- Abnormal membrane polarization
 - Cardiovascular
 - Neuromuscular
 - GI
 - Renal
 - Endocrine

Symptoms and Signs of Hypokalemia

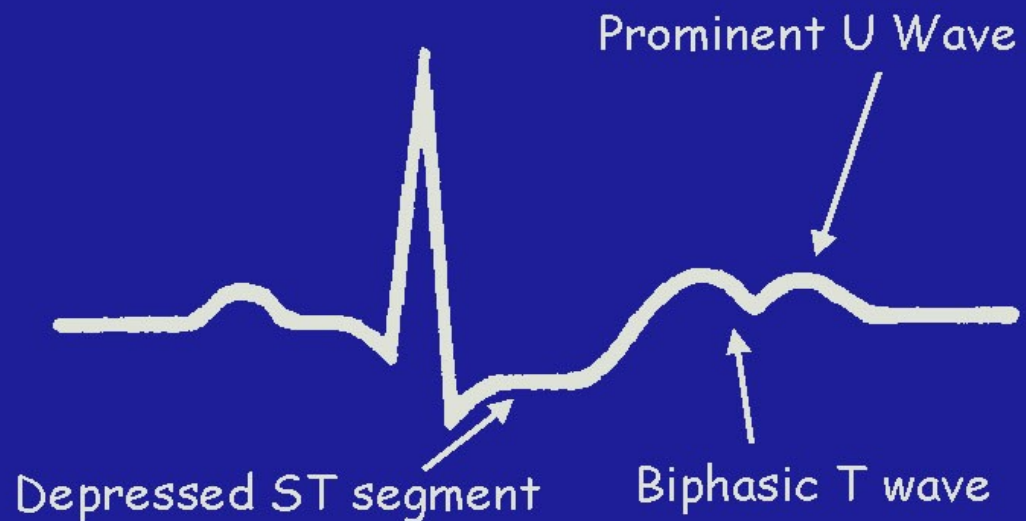


- Cardiovascular
 - Hypertension
 - Orthostatic hypotension
 - Potentiation of digital toxicity
 - Dysrhythmias (usually tachycardia)
 - ECG changes

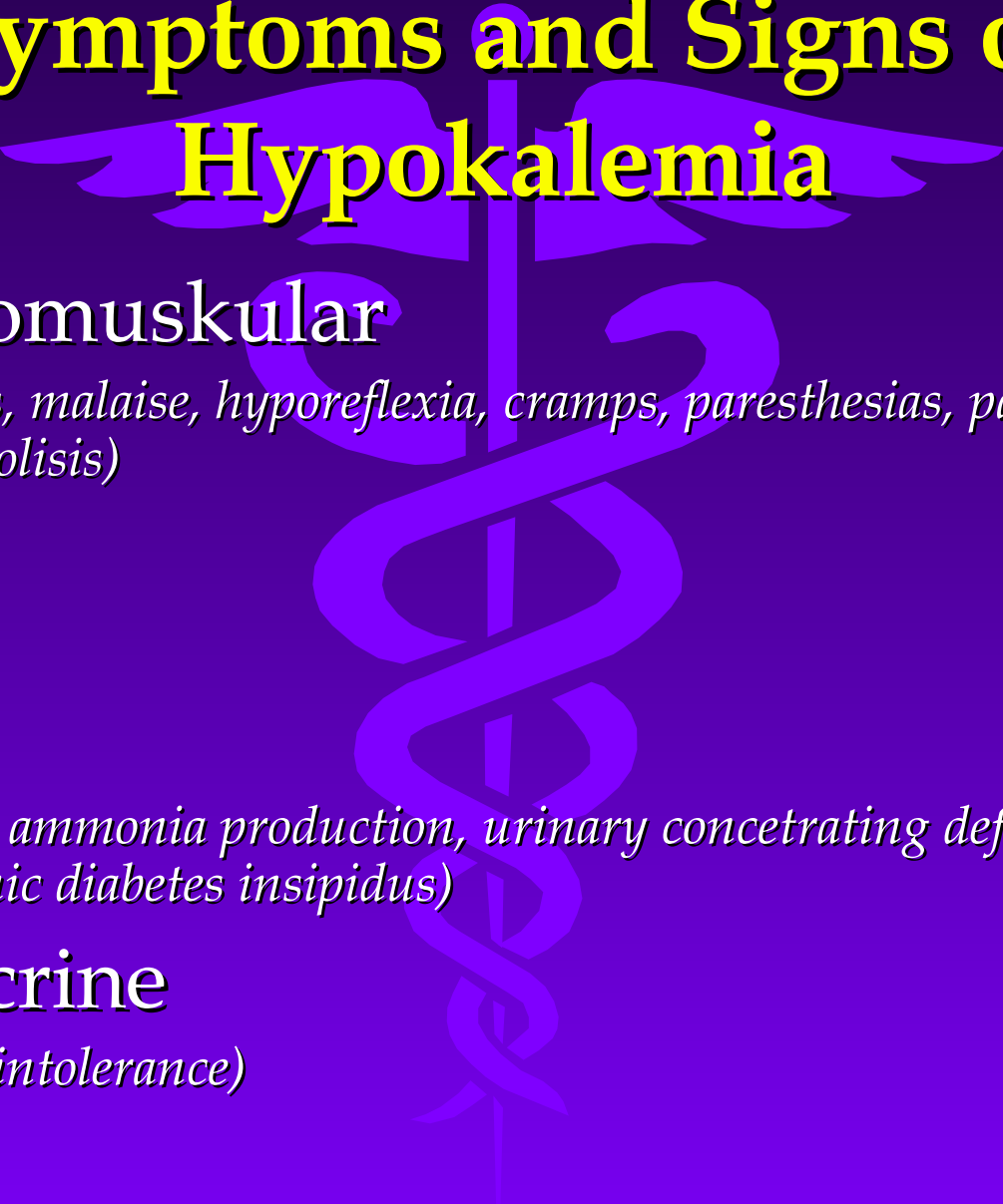
ECG Changes Associated with Hypokalemia

- U waves
- T-wave flattening
- ST depression

ECG Pattern of Hypokalemia



Symptoms and Signs of Hypokalemia



- Neuromuskular

(Weakness, malaise, hyporeflexia, cramps, paresthesias, paralysis, rhabdomyolysis)

- GI

(Ileus)

- Renal

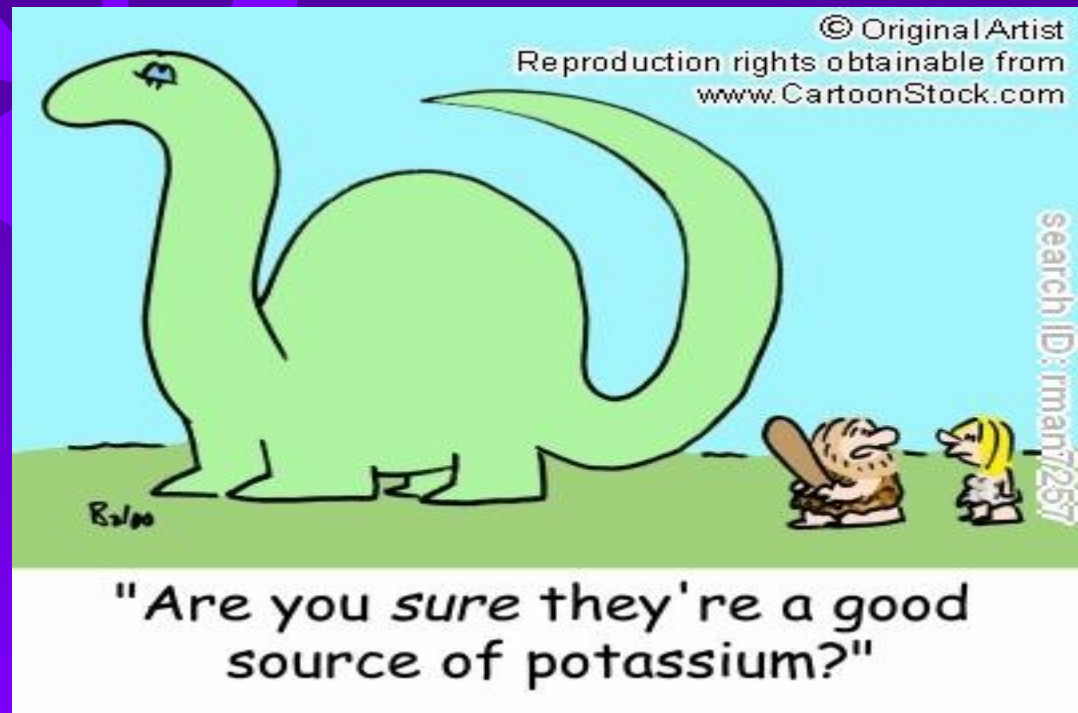
(Increased ammonia production, urinary concentrating defects, nephrogenic diabetes insipidus)

- Endocrine

(Glukose intolerance)

Treatment of Hypokalemia

- Oral intake for stable patients
- 20mEq per 30-60 min

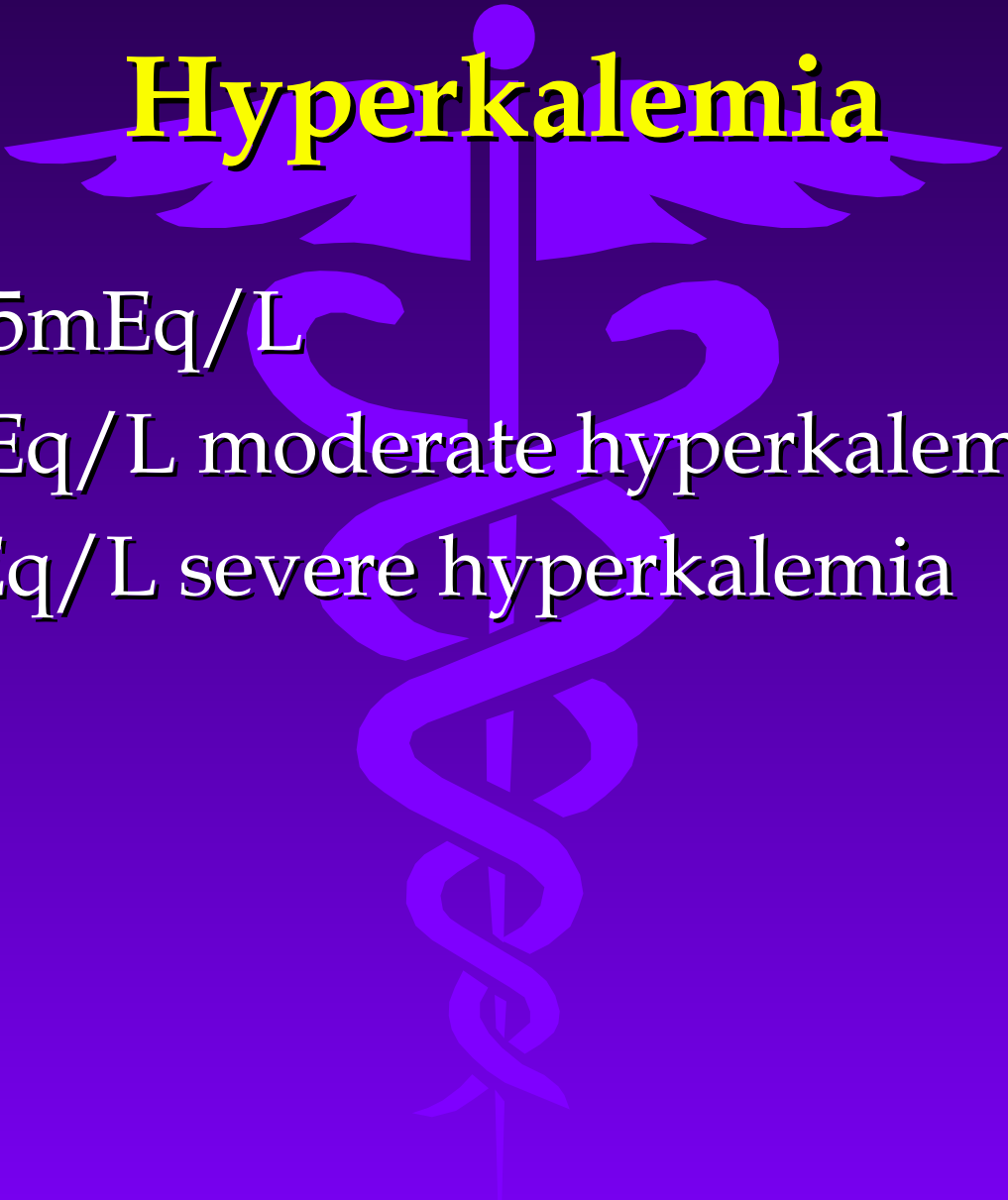


Treatment of Hypokalemia

- Severe hypokalemia or dysrhythmias ($K < 2.5 \text{mEq}$) $\Rightarrow$ IV treatment
- IV infusion rates should be $10\text{-}20 \text{mEq/h}$ (max 40mEq/h)
 - max 40mEq should be added to each litre of IV fluid
 - $> 20 \text{mEq/h} \Rightarrow$ Cardiac monitoring



Hyperkalemia

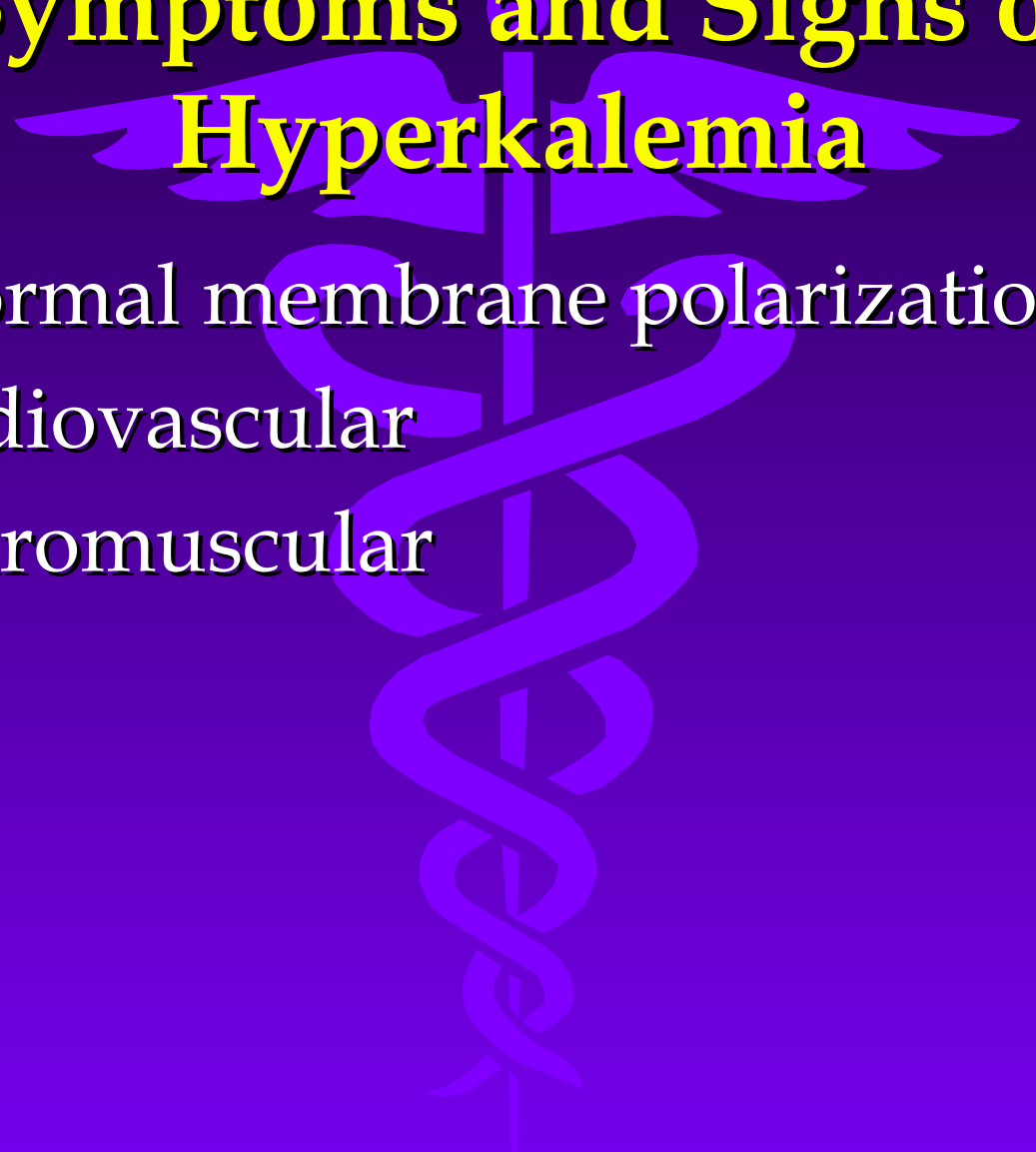


- $K > 5.5 \text{ mEq/L}$
- $6-7 \text{ mEq/L}$ moderate hyperkalemia
- $> 7 \text{ mEq/L}$ severe hyperkalemia

Causes of Hyperkalemia

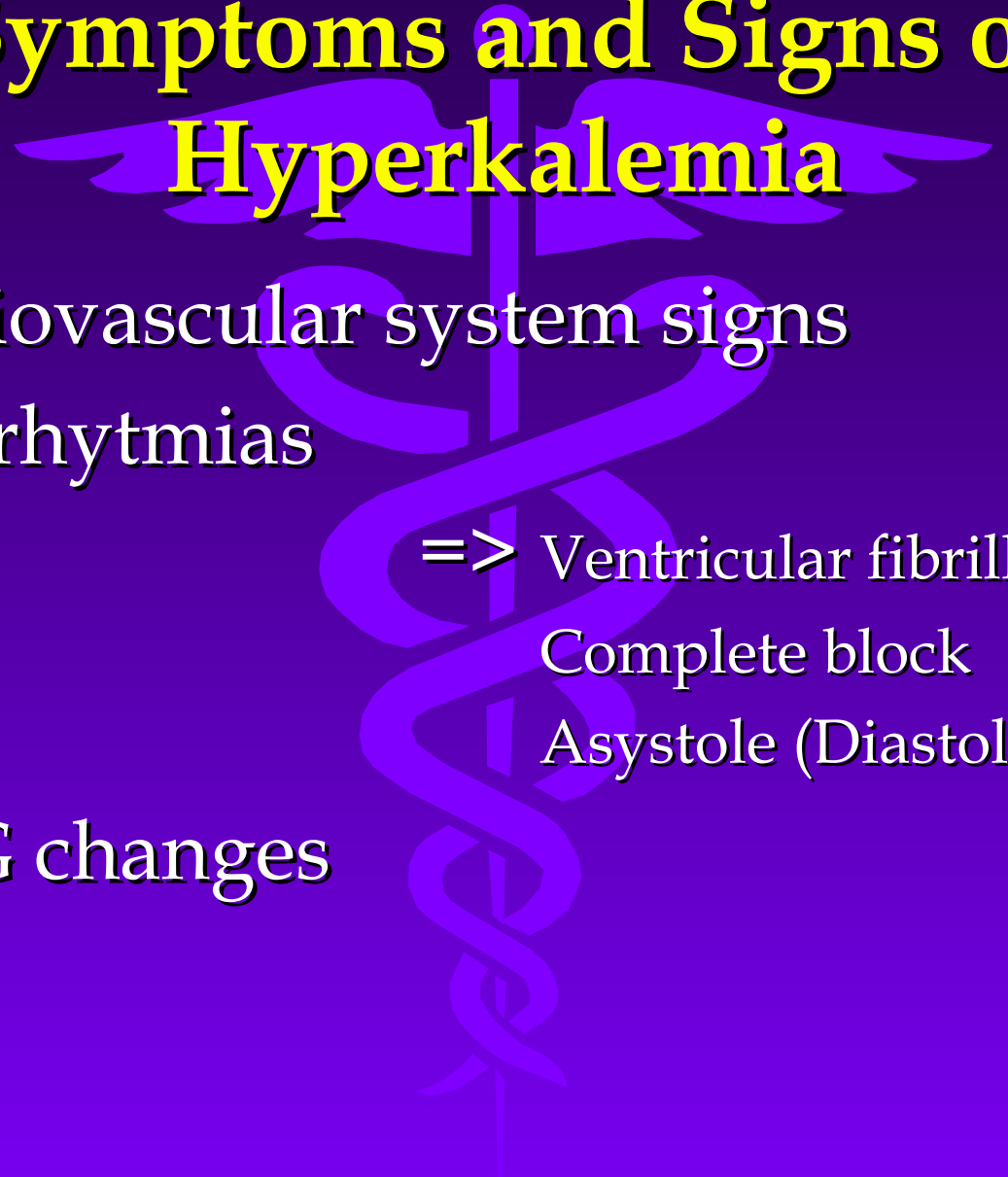
- Pseudohyperkalemia
(Tourniquet use, hemolysis, leukocytosis, thrombocytosis)
- Extracellular K shift
(Asidosis, heavy exercise, beta-blockade, insulin deficiency, digitalis intoxication, hyperkalemic periodic paralysis)
- K load
(K supplements, IV K, K containing drugs, hemolysis, chemotherapy, rhabdomyolysis, extensive tissue injury)
- Decreased K excretion
(Renal failure, K sparing diuretics, ACE inhibitors, aldosterone deficiency, pseudohypoaldosteronism, SLE, obstructive uropathy, type IV RTA)

Symptoms and Signs of Hyperkalemia



- Abnormal membrane polarization
 - Cardiovascular
 - Neuromuscular
 - GI

Symptoms and Signs of Hyperkalemia

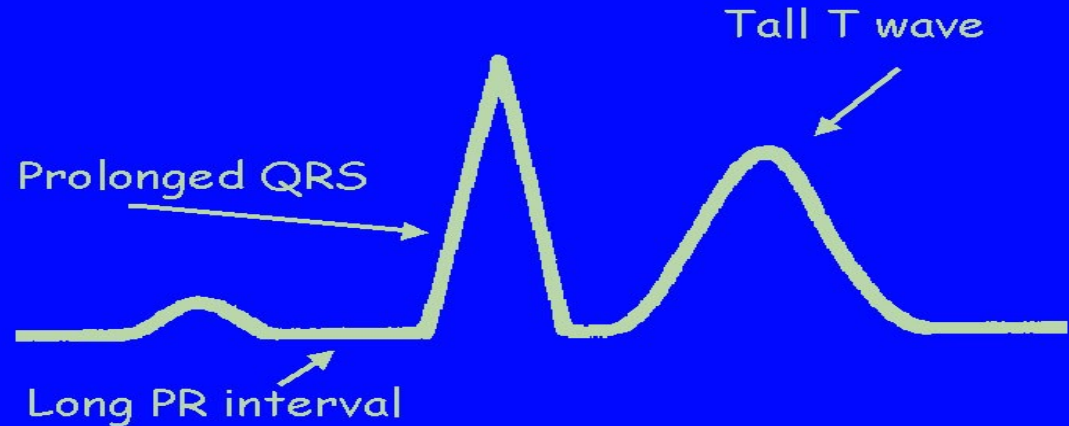
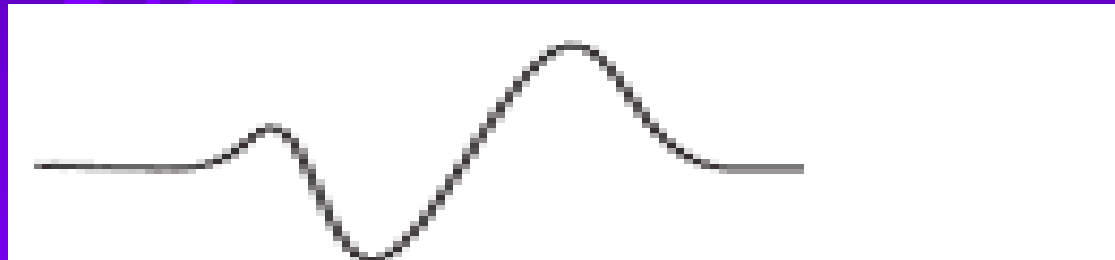


- Cardiovascular system signs
 - Dysrhythmias
 - => Ventricular fibrillation
 - Complete block
 - Asystole (Diastolic arrest)
 - ECG changes

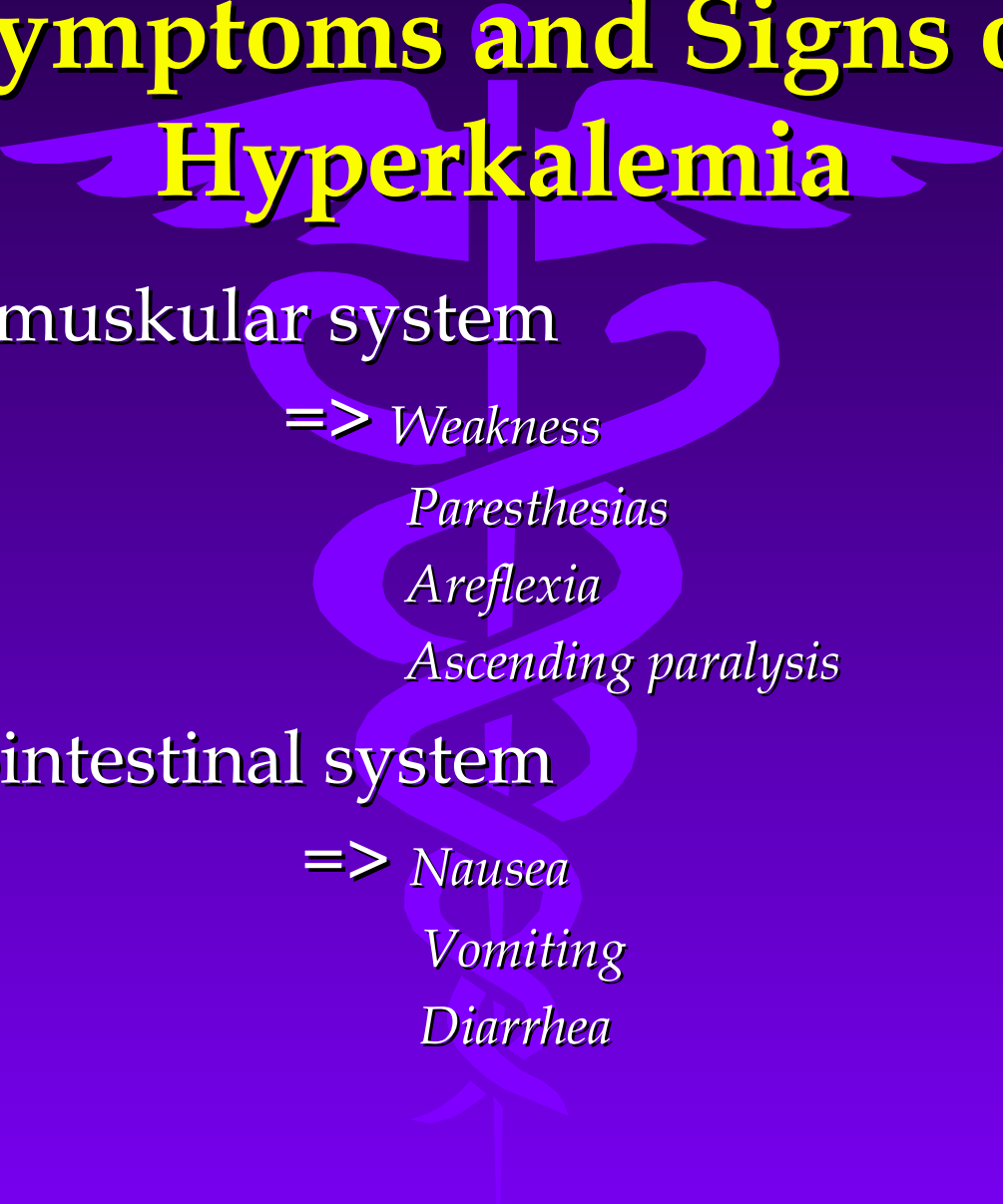
ECG Changes Associated with Hyperkalemia

- 6.5-7.5mEq/L
 - Prolonged PR interval
 - Tall peaked T waves
 - Shorten QT interval
- 7.5-8.0mEq/L
 - Flattening of the P wave
 - QRS widening
- 10-12mEq/L
 - QRS degradation into a sinusoidal pattern

ECG Pattern of Hyperkalemia



Symptoms and Signs of Hyperkalemia



- Neuromuskular system

=> *Weakness*

Paresthesias

Areflexia

Ascending paralysis

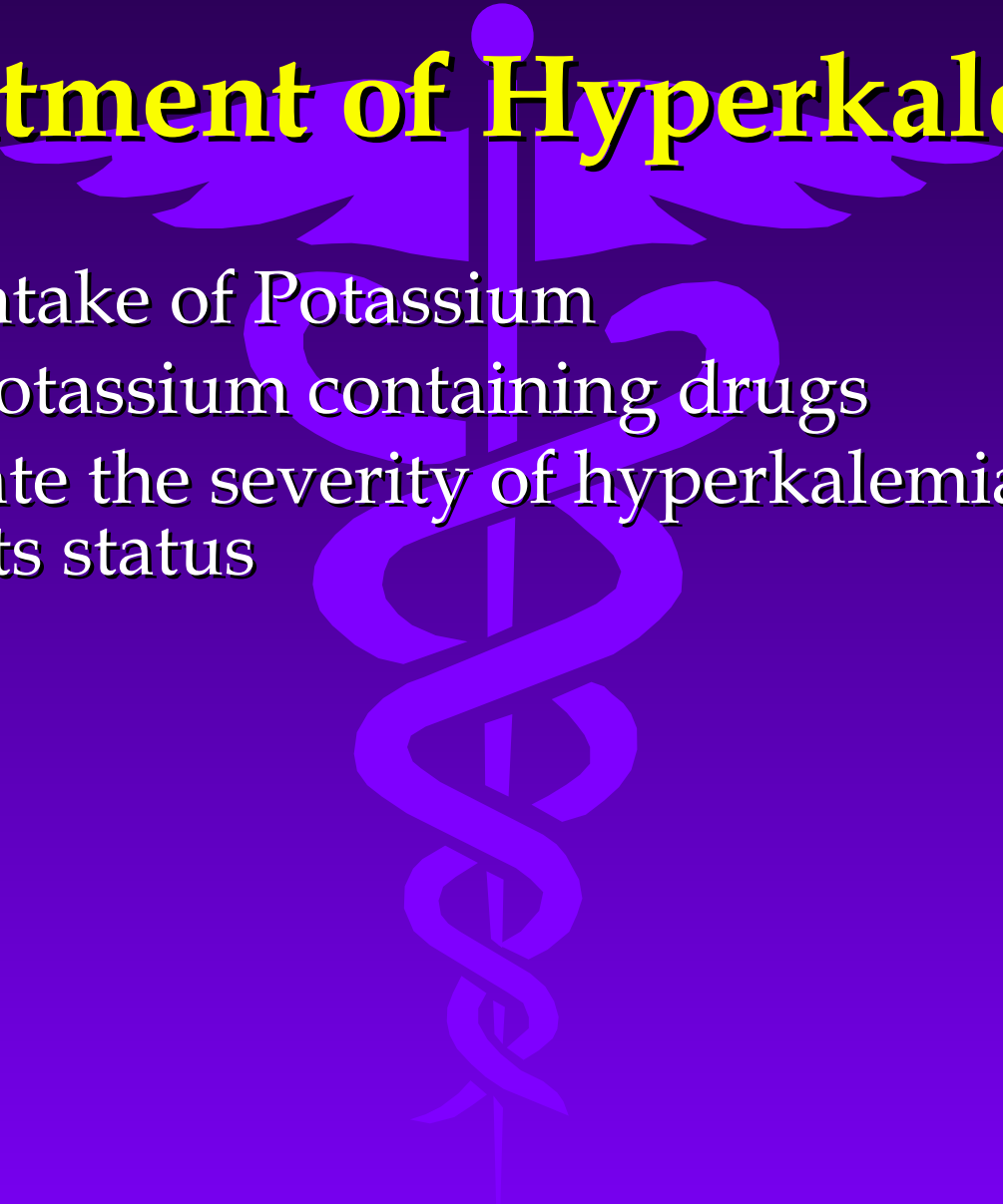
- Gastrointestinal system

=> *Nausea*

Vomiting

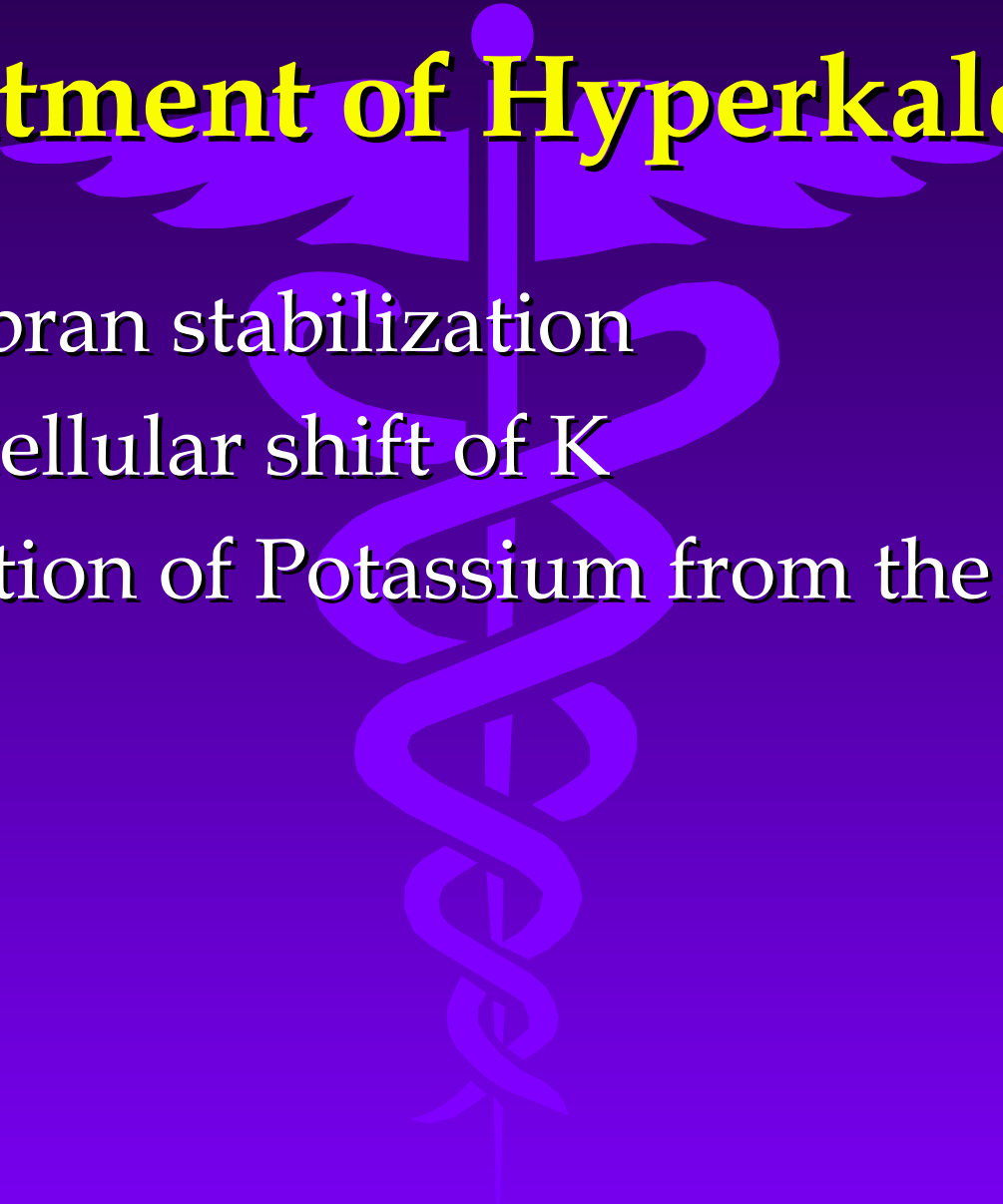
Diarrhea

Treatment of Hyperkalemia



- Stop intake of Potassium
- Stop Potassium containing drugs
- Evaluate the severity of hyperkalemia and patients status

Treatment of Hyperkalemia



- Membran stabilization
- Intracellular shift of K
- Excretion of Potassium from the body

Treatment of Hyperkalemia

- Relative Hyperkalemia (5-6mEq/L) & Asymptomatic
 - => Treat the underlying disorder
 - => -Diuretics (furosemid 40-80 mg IV)
 - Kayeksalat 15-30 gr oral

Treatment of Hyperkalemia

- Moderate hyperkalemia (6-7mEq/L)
 - Glukose&insulin:
25gr glukose(50 ml D50)+10 U insulin /30 dk
 - Na HCO₃:
50-100mEq IV / 5 min
 - Albuterol (nebulized):
10-20 mg / 15 min

Treatment of Hyperkalemia

- Severe hyperkalemia (>7 mEq/L)
 - Ca chloride/ gluconate (%10):
500-1000 mg IV / 5 min
 - Na HCO₃:
50 mEq IV / 5 min
 - Glukose&Insulin:
25 g (50 ml D50) + 10 U insulin / 30 min
 - Albuterol (nebulized):
10-20 mg /15 min
 - Furosemide:
40-80 mg IV
 - Kayekselat:
15-50 gr oral
 - Hemodialysis

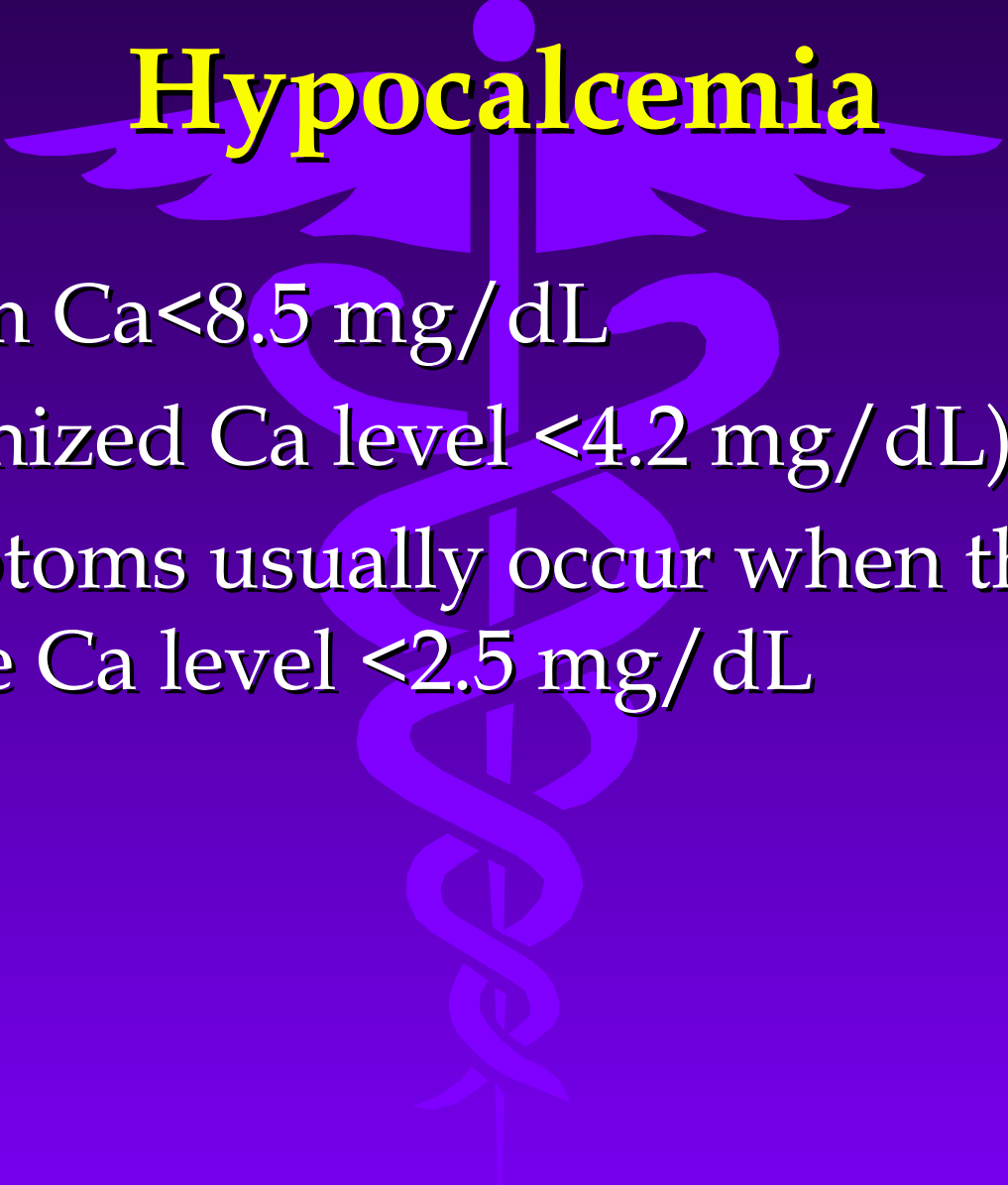


Calcium

- Normal plasma level 8.5-10.5 mg/dL
- PTH, vit-D and calcitonin
- Ionized fraction is active
- 1 gram decrease in albumin
=> Decrease total Ca level 0.8 mg/dL

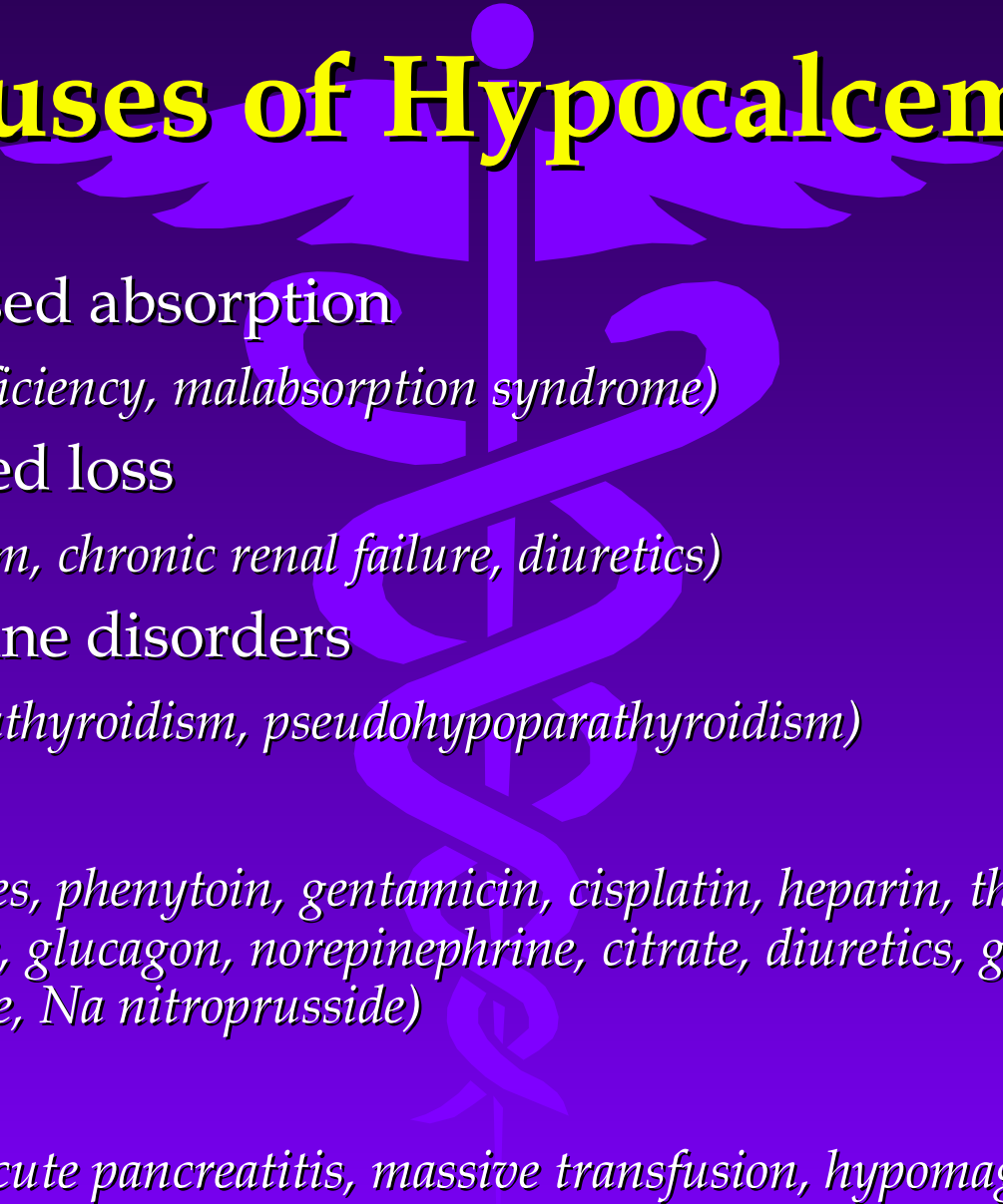
$$\text{Corrected Ca} = \text{Patients Ca} + [(4 - \text{Patients alb.}) \times 0.8]$$

Hypocalcemia



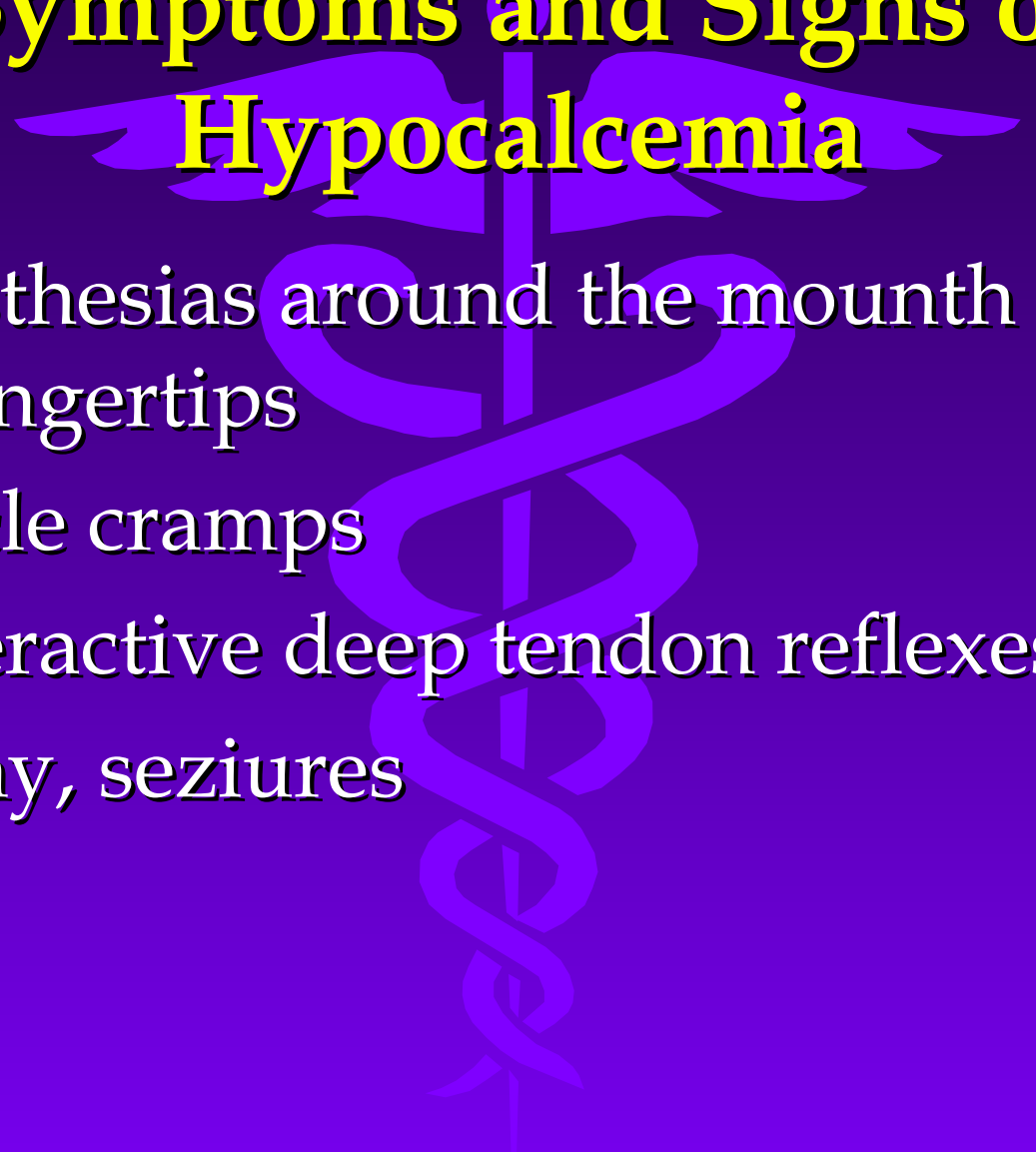
- Serum Ca < 8.5 mg/dL
(or ionized Ca level < 4.2 mg/dL)
- Symptoms usually occur when the ionized Ca level < 2.5 mg/dL

Causes of Hypocalcemia



- Decreased absorption
(Vit-D deficiency, malabsorption syndrome)
- Increased loss
(Alcoholism, chronic renal failure, diuretics)
- Endocrine disorders
(Hypoparathyroidism, pseudohypoparathyroidism)
- Drugs
(Phosphates, phenytoin, gentamicin, cisplatin, heparin, theophylline, protamine, glucagon, norepinephrine, citrate, diuretics, glucocorticoid, Mg sulfate, Na nitroprusside)
- Other
(Sepsis, Acute pancreatitis, massive transfusion, hypomagnesemia, rhabdomyolysis)

Symptoms and Signs of Hypocalcemia



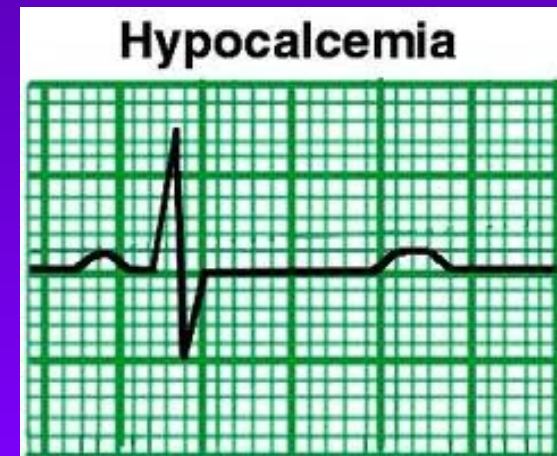
- Paresthesias around the mouth or in the fingertips
- Muscle cramps
- Hyperactive deep tendon reflexes
- Tetany, seiures

Symptoms and Signs of Hypocalcemia

- Chvostek-Trousseau signs



- ECG changes
 - => Prolonged QT interval
 - Prolonged ST segment



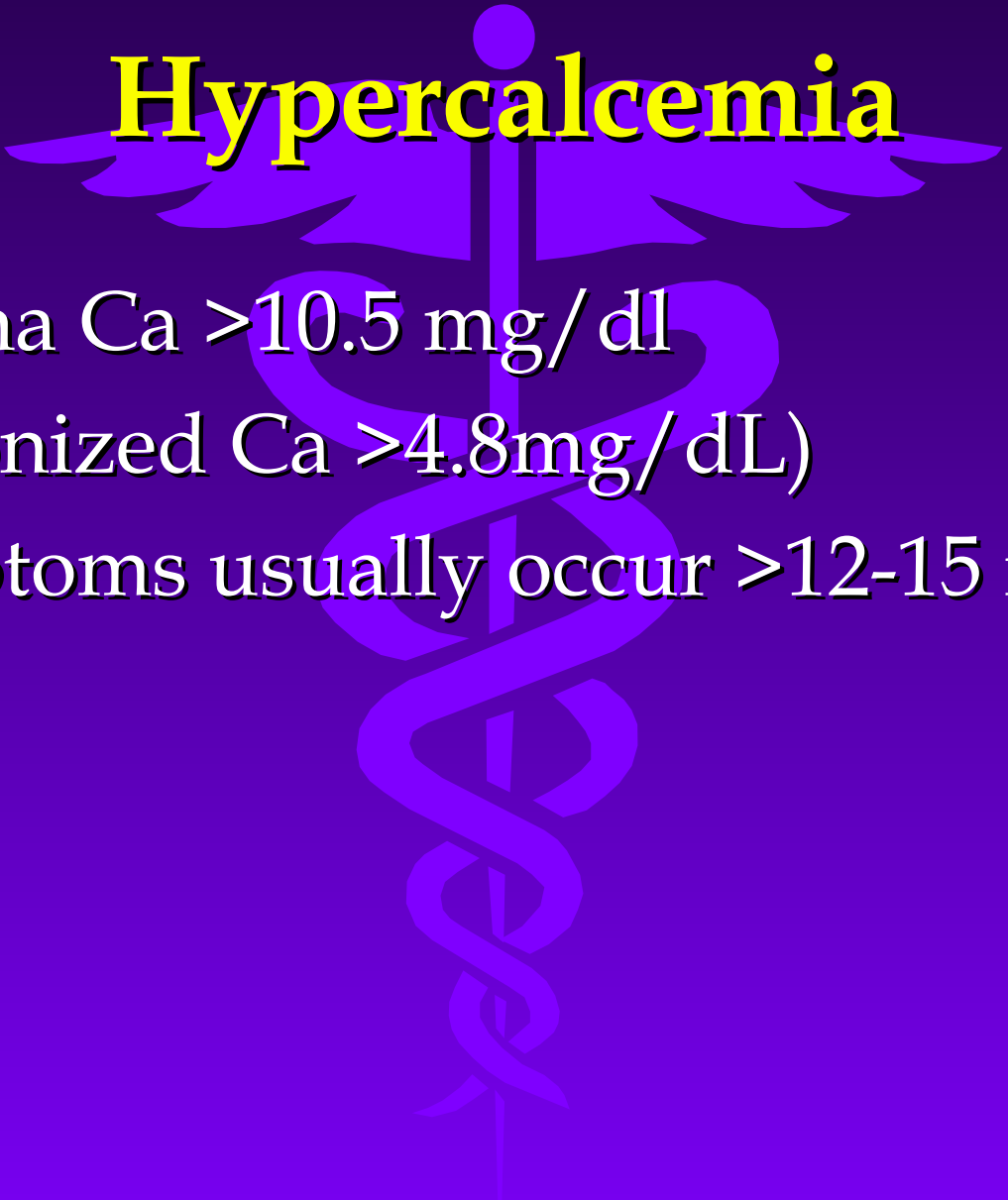
Treatment of Hypocalcemia

- Asymptomatic-mild-prolonged hypocalcemia (>10-14 gün)
=> Oral therapy
(1500-3000 mg Ca / day)

Treatment of Hypocalcemia

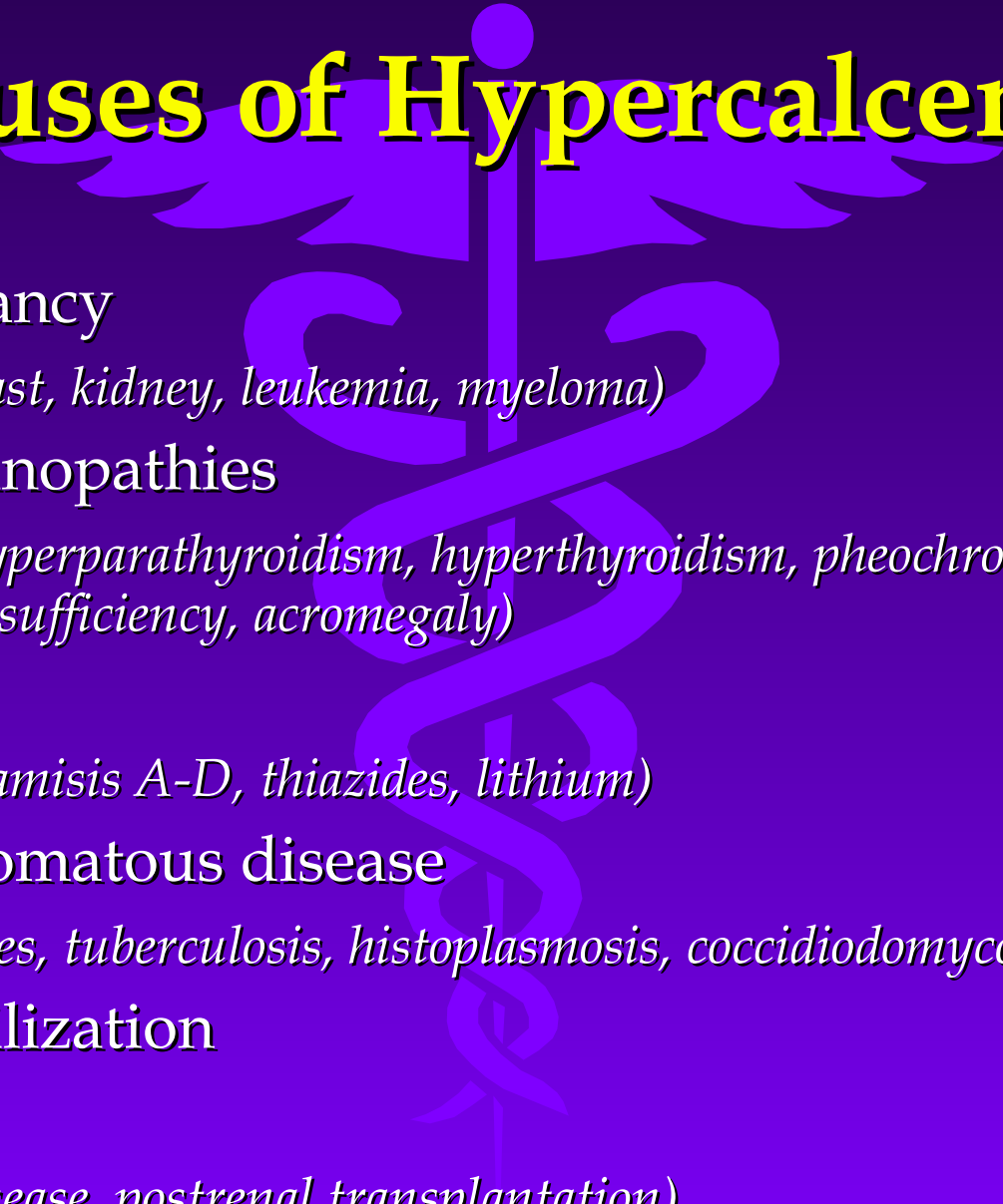
- Symptomatic or severe hypocalcemia
=> IV Ca
(10 ml of %10 CaCl_2 IV / 20 min
followed by 0.02ml/kg/h infusion)
- Magnesium

Hypercalcemia



- Plasma Ca >10.5 mg/dl
(or ionized Ca >4.8 mg/dL)
- Symptoms usually occur $>12-15$ mg/dL

Causes of Hypercalcemia



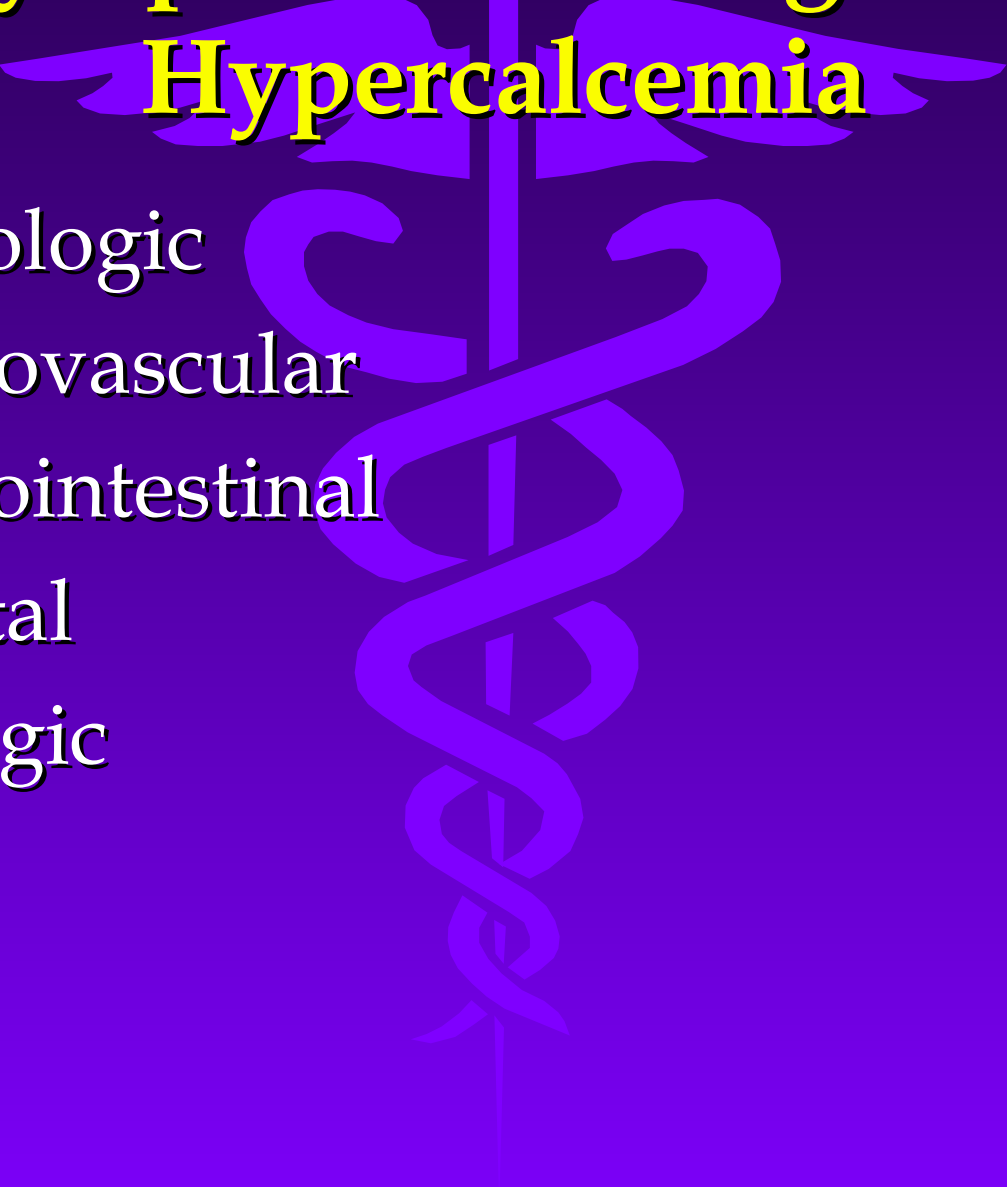
- Malignancy
(Lung, breast, kidney, leukemia, myeloma)
- Endocrinopathies
(Primer hyperparathyroidism, hyperthyroidism, pheochromacytoma, adrenal insufficiency, acromegaly)
- Drugs
(Hypervitamins A-D, thiazides, lithium)
- Granulomatous disease
(Sarcoidoses, tuberculosis, histoplasmosis, coccidioidomycosis)
- Immobilization
- Other
(Paget disease, postrenal transplantation)

Symptoms and Signs of Hypercalcemia

- Weakness, malaise, polydipsia, dehydration
- Conjunctivitis
- Band keratopathy
- Pruritus

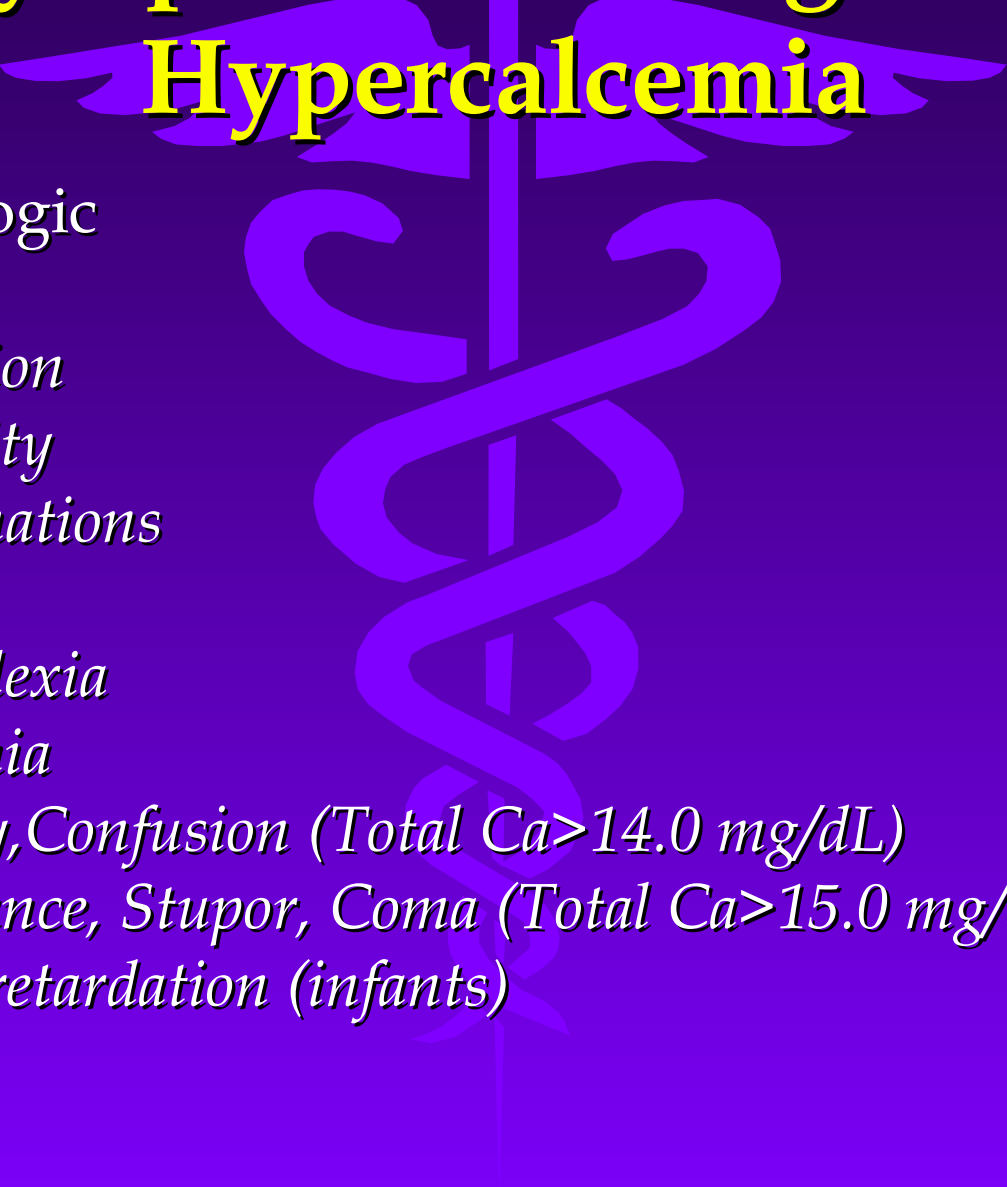


Symptoms and Signs of Hypercalcemia



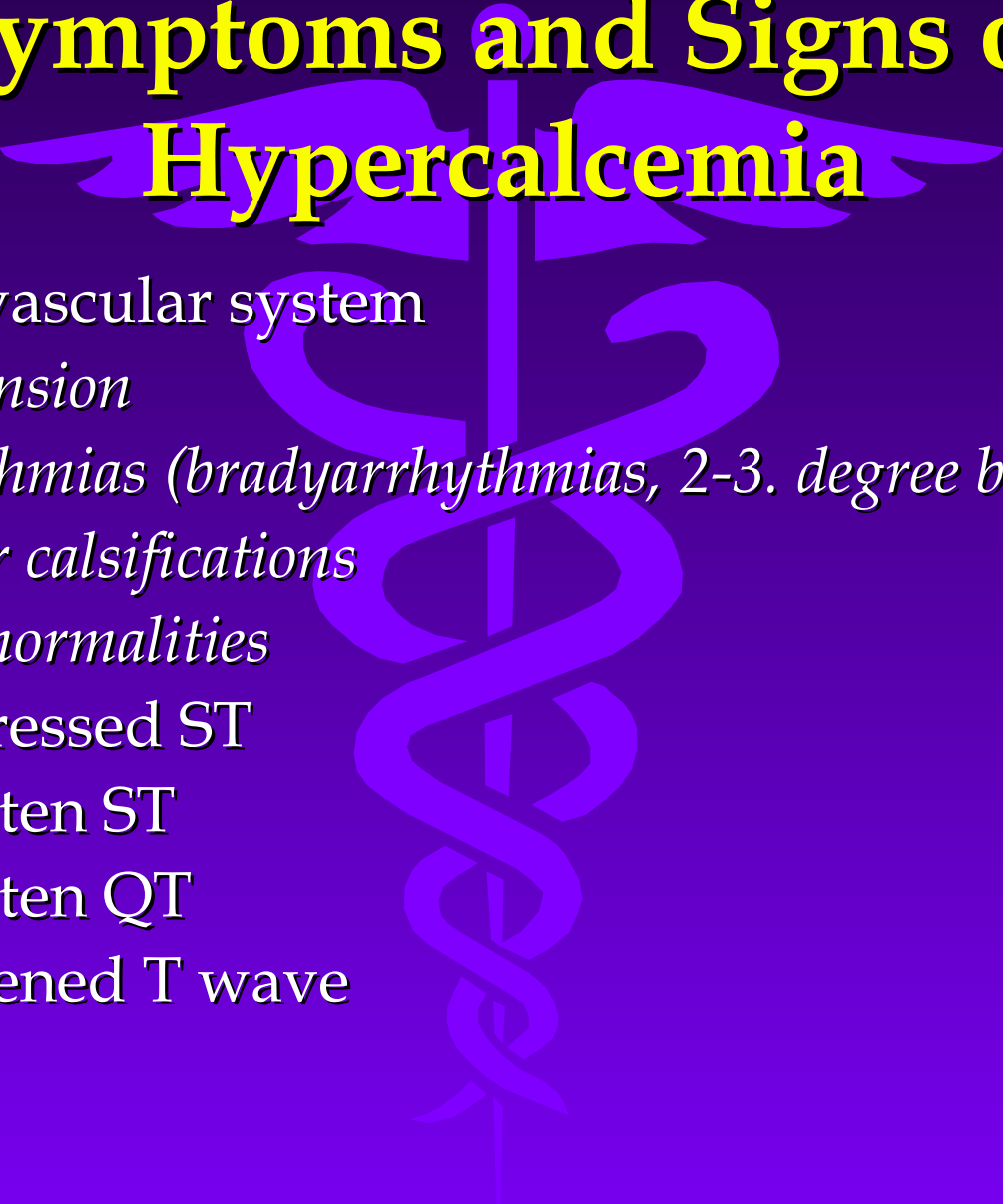
- Neurologic
- Cardiovascular
- Gastrointestinal
- Skeletal
- Urologic

Symptoms and Signs of Hypercalcemia



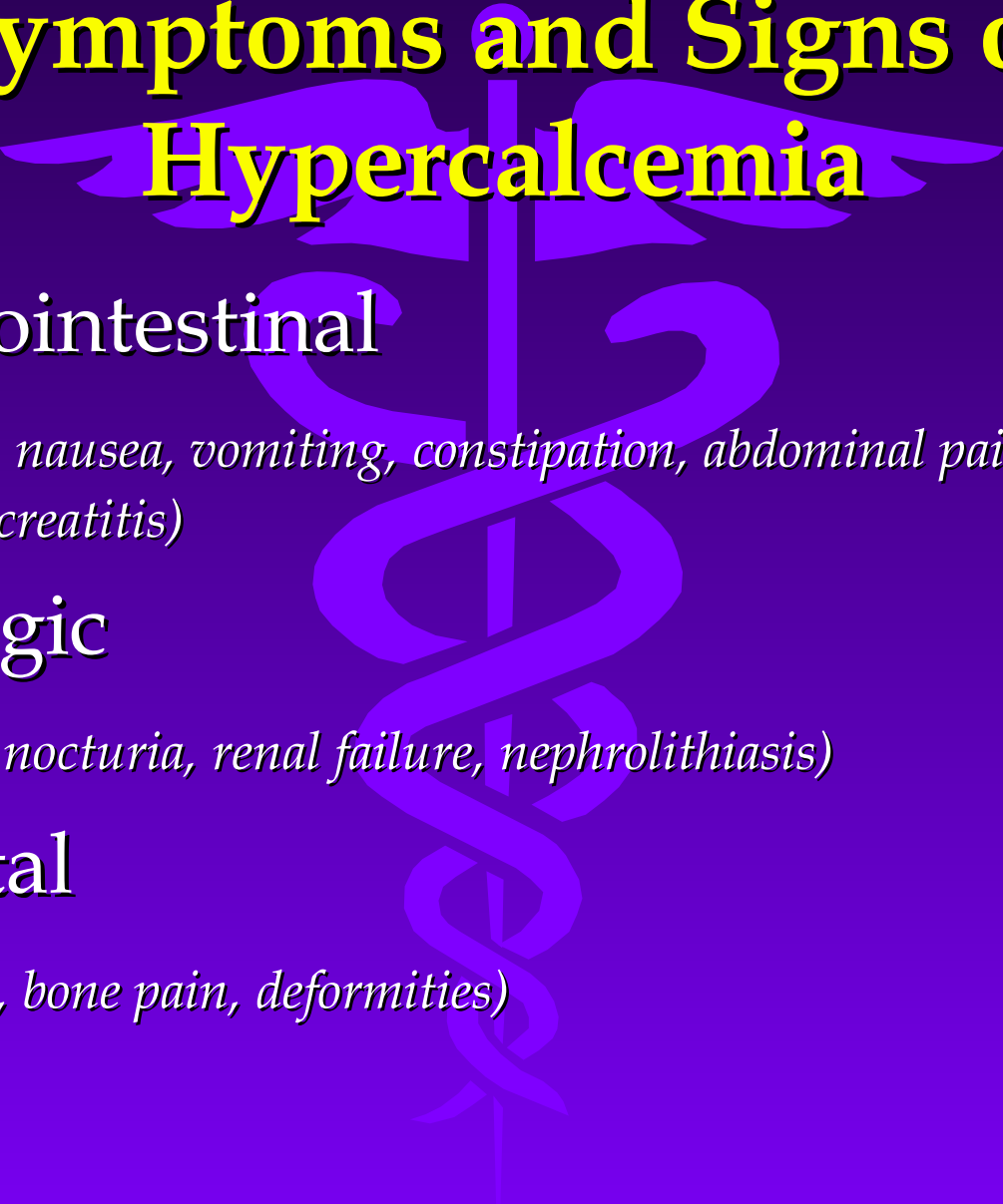
- Neurologic
 - Apathy*
 - Depression*
 - Irritability*
 - Hallucinations*
 - Ataxia*
 - Hyporeflexia*
 - Hypotonia*
 - Lethargy, Confusion* (Total Ca > 14.0 mg/dL)
 - Somnolence, Stupor, Coma* (Total Ca > 15.0 mg/dL)
 - Mental retardation* (infants)

Symptoms and Signs of Hypercalcemia



- Cardiovascular system
 - Hypertension
 - Dysrhythmias (bradyarrhythmias, 2-3. degree block)
 - Vascular calcifications
 - ECG abnormalities
 - => Depressed ST
 - Shorten ST
 - Shorten QT
 - Widened T wave

Symptoms and Signs of Hypercalcemia



- Gastrointestinal

(Anorexia, nausea, vomiting, constipation, abdominal pain, peptic ulcer, pancreatitis)

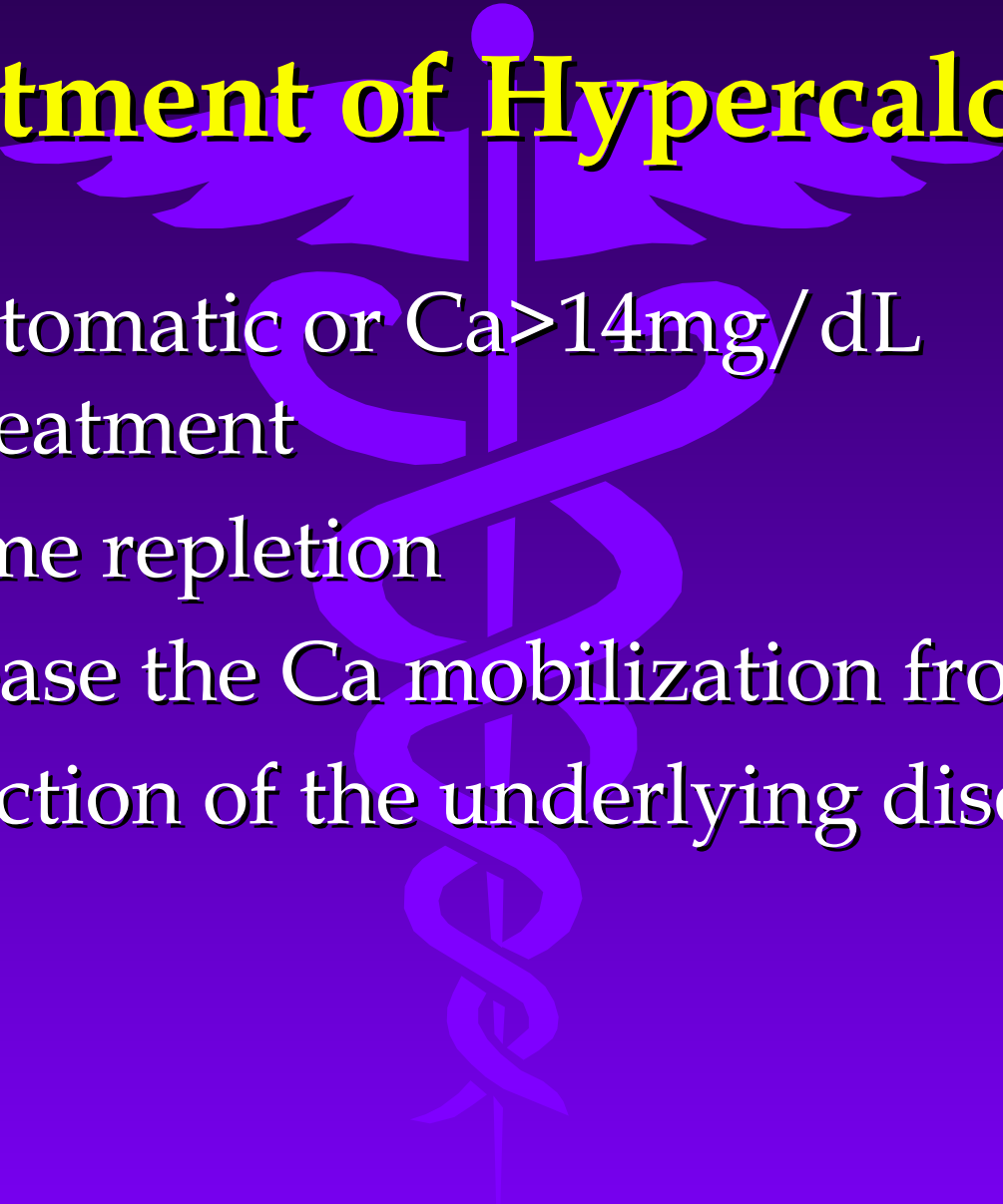
- Urologic

(Polyuria, nocturia, renal failure, nephrolithiasis)

- Skeletal

(Fractures, bone pain, deformities)

Treatment of Hypercalcemi



- Symptomatic or $\text{Ca} > 14 \text{ mg/dL}$
=> Treatment
- Volume repletion
- Decrease the Ca mobilization from bone
- Correction of the underlying disorder

Treatment of Hypercalcemi

- Bisphosphonats
 - => - Pamidronate
(90mg/24 h IV)
 - Etidronate
(7.5mg/kg/day IV)
 - Zoledronic acid
(4mg/15 min IV)

Treatment of Hypercalcemi

- No longer recommended

=> Diuretics

Mithramycin



Gallium

IV Phosphates



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